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EDITORIAL

THE PRODUCTION OF ATTRACTIVE FRUIT

IN recent issues of *The Tropical Agriculturist* attention has been called to some of the various aspects of fruit cultivation and emphasis has been laid on the importance, first of all, of choosing localities and soil conditions best suited for the different kinds of fruit, secondly, of employing sound methods of propagation and thirdly, of paying due regard to the various cultural operations considered essential for the production of the best quality of fruit.

As indicated previously, Ceylon is endowed with an unusually wide range of tropical and semi-tropical fruits which are likely to respond favourably to any systematic attempts which may be made to improve their quality. Within recent times, however, some of the pioneers of fruit-growing in Ceylon have found by experience that if they are to compete successfully with imported fruit something more than actual quality is needed. This locally grown fruit will always stand a better chance in competition with similar varieties of imported fruit when it possesses an attractive appearance and is of a fashionable colour; this applies especially to citrus fruit, such as oranges and grapefruit.

Most citrus-growing countries have found it necessary to adopt artificial methods for colouring their fruit, and Ceylon in her efforts to develop a local fruit industry, while paying due attention to the production of quality, must not overlook the rather important essentials of correct colour and attractive appearance.

This aspect of fruit-production has not been neglected by the Department, and in this issue appears an article on some of the recent work done by the Chemical Division in the Artificial Colouring and Ripening of Fruit. The two chief methods by which fruit can be coloured are explained and notes are given on the various modifications of the colouring process required for such fruits as oranges, grapefruit, plantains or bananas, mangoes, pineapples, etc. It is of interest to note that the colouring process also tends to hasten the maturity and to enhance the flavour of fruit so treated. Successful results in the colouring of fruit have already been obtained by a few progressive local fruit-growers, and it is hoped that the information detailed elsewhere will stimulate others to follow their example.

THE ARTIFICIAL COLOURING AND RIPENING OF FRUIT

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INTRODUCTION

WITH the coming into bearing of small areas of citrus planted a few years ago when the impetus to fruit cultivation in Ceylon was first given, a number of enquiries has been received by the Department as to how the poor colour of local fruit can be improved. As is well known Ceylon oranges and mandarins, especially those grown in the low-country, do not assume the rich colour so characteristic of imported varieties, but remain green or slightly coloured even when they are quite matured and fit for eating. Our grapefruit are also generally unattractive in appearance, being neither green nor yellow. This lack of development of normal colouration when ripe is not confined to Ceylon citrus fruit only. It is reported to occur in California, Florida, etc., with certain varieties of oranges, during certain seasons and under certain climatic conditions. If left to become fully coloured, the quality of the fruit deteriorates. Lemons are invariably picked, even though green in colour, if they have attained the standard size. They have thus always been "cured" for normal colour development before being marketed.

In view of the extensive adoption of the practice of artificial colouration in some citrus growing countries and the interest taken in the process locally, investigations were carried out in the Chemical Laboratory on this and the closely connected problem of the artificial ripening of fruit. It is claimed by users of these processes that fruit and vegetables so treated are not only coloured or blanched, but also ripened in a shorter period than would normally be the case. In the following pages will be summarised the information obtained on these related subjects from the literature and as a result of work done here.

HISTORICAL

It is reported by Harvey [1] that the Chinese have from ancient times effectively ripened hard pears by enclosing them in a chamber in which incense was burnt. In Ceylon it is not an uncommon practice to smoke plantains in a covered hole in order

to hasten ripening. Lemons in the past have been cured or coloured by a "sweating" process in which high temperatures and humidities play an important part, the heat being supplied by kerosene oil stoves. Since Sievers and True [3] in 1912 showed that the colouring was mainly brought about by the gaseous combustion products of the stoves, the process has been considerably improved upon. These authors also demonstrated that the exhaust gases of motor engines had the same effect on fruit, but that their use was expensive. It was left to Denny [3, 4] in 1924 to discover that the chief agent of kerosene stove gas responsible for the colouring was the unsaturated hydrocarbon gas ethylene. Since then he and Harvey [1] found that other unsaturated gases like proplylene and acetylene have the same property of hastening the colouring and, in certain cases, the ripening of fruit. Neither of these gases has however been used on a commercial scale in the past, as the former, though very efficacious for the purpose, is not easily available in large quantities, while the latter has the disadvantages of a disagreeable odour and of tainting the flavour of the treated fruit. Within recent times however acetylene has been used with success for colouring citrus varieties after due precautions were taken. The use of ethylene for the colouring and ripening of fruit and the blanching of vegetables has since been investigated by several workers and the process is now adopted commercially in the various States of America and Australia with very satisfactory results.

PREPARATION AND PROPERTIES OF ETHYLENE

Before detailing the method of colouring it would be useful to explain how ethylene can be prepared and to describe such of its properties as relate to the process. Ethylene is prepared by heating ethyl alcohol with an excess of concentrated sulphuric or phosphoric acid to a temperature of about 165°C, a little sand or a few pieces of glass being added to the container to prevent bumping. The evolved gas is passed through caustic soda to free it of sulphur dioxide and is then quite suitable for use. With 20 c.c. of alcohol and 60 c.c. of concentrated sulphuric acid, it is reckoned that about 1/4 c. ft. of gas can be produced. For industrial purposes cylinders of compressed ethylene are available. These cylinders are not obtainable locally but can be imported from England and America. Particulars of cost, etc., can be supplied by the writer to anyone who requires them. At least one such apparatus is in use in Ceylon at present, but for most users or intended users of the process who deal with comparatively small quantities of fruit, expenditure on such an apparatus is not necessary.

Ethylene is a colourless, faintly sweet-smelling gas of about the same density as air. It will thus easily diffuse to any part of a chamber or crate into which it is passed. When mixed with air in proportions above 3 per cent. by volume, it forms an explosive mixture. In the concentrations in which it is used for colouring purposes, however, it is quite safe. But when using it care should be taken that no flame is brought near the gas issuing outlet. Ethylene may also be used as an anaesthetic, but in the concentrations required for this work, it is absolutely harmless.

How ethylene brings about the change in colour of fruits and effects ripening is not yet well understood. Some writers suggest that the effect of ethylene on ripening is due, in part at least, to the increase in permeability of the cells to oxygen [10, 12] as shown by a reduction of the respiratory quotient. Others consider that it stimulates enzyme action [1]. What however, is clear, is that oxygen is essential for the process [3, 6]. Hardy [6] states that the change in colour of the fruit is brought about by the destruction of the chlorophyll by the oxygen and the unmasking of the colouring matters of the rind.

THE ETHYLENE COLOURING AND RIPENING PROCESS

The actual process of colouring is very simple. The fruit after being well washed and dried is placed in a chamber in crates or loose on shelves. The chamber may be of wood or even of masonry, but it must be as airtight as possible and have a door and a window for ventilation. Through a small opening in the chamber ethylene gas is passed either from cylinders or from a gas generating plant. A very convenient proportion of gas to work with is 1 of the latter to 1,000 parts of air. Concentrations of ethylene as small as 1 in 200,000 parts of air have, however, been found to be efficacious with certain types of fruit, but the time for ripening or colouration is longer. A moderate excess of gas is not harmful, but very high concentrations apart from causing spotting of the fruit, may be dangerous for other reasons stated. The temperature in the chamber should be from 65°F. to 80°F., the optimum being about 70°F. The average Ceylon temperature range is somewhere near the higher limit and would, therefore, be suitable for most fruit. Temperatures higher than 93°F. retard the colouration. The relative humidity range varies from 75 to 90 per cent. with different fruits. It can be controlled by introducing an open vessel of water into the chamber if a high humidity is required. Quicklime, sand or caustic soda is used to produce a low humidity.

After the first charge of gas the chamber is kept closed for about eight to ten hours, at the end of which period it is well aired for about an hour or two and then given a second charge. Ventilation is very essential for the reason already explained. This procedure is repeated each day, with two, or three charges a day till the fruit is coloured. The length of time taken will vary with the variety of the fruit and its degree of maturity, the more mature the fruit the shorter the time required for colouring. It is not essential that the fruit should be coloured fully if it is to be retained for a few days before it is sold. Once the colouring has started it will continue till full colouration or maturity is reached.

As a result of the gas treatment the "buttons", or attachments of the stem to the fruit, will often drop. This is because the cells around the buttons enlarge through the stimulation of growth by the treatment. The falling away of the buttons was regarded in the past as a disadvantage owing to the danger of fungal infection through the opening. The contrary opinion is now held. Button fall can be prevented to some extent by frequent changes of gas and good aeration. One precaution is very necessary where fruit is artificially coloured. They should not be bruised in any way. With citrus, bruises are shown up as green patches. Thorough washing of the fruit is also necessary, as any spray residues or sooty mould will prevent uniform colouring.

DOES ETHYLENE GAS HASTEN THE RIPENING OF FRUIT?

The statement that ethylene hastens the ripening of fruit has been made by many writers, but the evidence is not entirely confirmatory of this claim. In regard to certain varieties of citrus, (e.g. the orange), Chase & Church [5] have shown that there is no difference in composition between treated and untreated fruit. On the other hand while these authors obtained the same result with lemons, Sievers & True [2] showed that "forced" curing increased the amount as well as the acidity of juice in the fruit. It was known that oranges when picked green did not improve on keeping, unlike certain citrus varieties and other fruits, (e.g. pears, bananas, etc.), which when picked matured, though hard and inedible, ripened into quite edible fruit.

Analyses carried out in this laboratory on representative samples of the local variety of "squash" oranges and of local grown Valencias, treated and untreated with ethylene, confirmed the general findings of Chase & Church [5]. It was however noted that the treated fruit invariably had smaller amounts of total sugars than the untreated fruit. This is seen from the table below and is obviously due to the increased respiration brought about by the treatment.

Change in Composition of Oranges

Constituent	Variety	Original sample	Final sample Untreated	Final sample Treated
Acidity as citric acid %	Local 1	3·12	3·06	3·29
	Local 2	2·30	2·47	2·42
	Valencia	1·11	1·12	1·02
Reducing sugars %	Local 1	2·90	3·07	2·94
	Local 2	3·0	3·17	3·10
	Valencia	2·34	2·39	2·39
Sucrose %	Local 1	3·04	2·77	2·14
	Local 2	3·72	3·70	
	Valencia	2·75	2·84	2·63
Total sugars %	Local 1	6·13	5·98	5·19
	Local 2	6.92	7·06	6·52
	Valencia	5·23	5·38	5·16
Total solids %	Local 1	10·3	10·3	9·8
	Local 2	10·2	10·2	9·9
	Valencia	7·8	7·8	7·8
Density at 27°C	Valencia	1·027	1·028	1·028
Total solids/acidity	Local 1	3·3	3·4	3·0
	Local 2	4·4	4·1	4·0
	Valencia	7·0	7·0	7·8

This observation was also noted by the Russian workers [10] with cucumbers, tomatoes, mandarins and apples, and by Harvey [1] with pineapples. Hartshorn [14] showed that acetylene gas accelerated the ripening processes of green bananas as indicated by rates of softening, respiration, starch hydrolysis, flavour and colour changes. Increased respiration was also found by Denny [11] with lemons. In all these cases there was a marked increase in carbon dioxide production and oxygen consumption after treatment. On the other hand Wolff [8] working with bananas found that while fruit ripened with ethylene turned yellow at a somewhat more rapid rate than the controls, and showed slightly greater increases in sugars and decreases in starch from day to day than the latter, on the whole the differences were not very marked. Unlike Harvey [1] he found no differences in the rate of respiration between treated and untreated fruit. But he observed that when a bunch of bananas was in a quasi-dormant condition, ethylene stimulated an immediate commencement of ripening. Persimmons treated with ethylene were found by Chase & Church [5] to have their

astringency removed and to soften more quickly than untreated fruit. The colour of the latter was also inferior to that of the treated fruit. These authors also found that the colouring of bananas, of the seed arils of pomegranates, and of tomatoes was accelerated by ethylene. These observations are confirmed by the work of Harvey, Rosa and others [1]. Kohman [9] however found that with tomatoes there was no difference between the rate of colouring of treated and untreated fruit unless they were picked at such an immature stage that they would not have developed the red colour if left on the vine. In regard to dates while Chase & Church [5] found no change in composition between treated and untreated fruit, Harvey [1] reported that ethylene hastened the ripening and the removal of tannins from the fruit.

The experience of the writer in regard to mangoes is that the colouring of varieties of this fruit which colour naturally is hastened by the use of ethylene. The Jaffna mango which is green when ripe does not, however, become yellow, but takes on a yellowish green tinge. The ripening of the fruit, as discerned by flavour, odour and softness is accelerated by the process. The ripening of plantains was certainly hastened by the process, and such varieties like the ash plantain, which normally are only used for cooking, were found to ripen like the eating varieties. Local users of the ethylene process report that matured pineapples can be made to ripen in a much shorter time by the use of ethylene than would normally be the case. The astringency of mature sapodillas can likewise be entirely removed. On the whole the evidence indicates that while the process cannot be used to ripen certain citrus fruit like oranges and grapefruit, it is of great value in hastening the ripening of a number of varieties of other fruit.

THE ACETYLENE PROCESS

The acetylene process for the colouration of fruit is carried out in the same manner as the ethylene process, the only difference being that in this case the gas is acetylene, obtained by the action of water on calcium carbide. The latter is generally placed in a dish inside the chamber and sufficient water to saturate the carbide is added in small quantities from outside by means of some clip device. The proportion of acetylene gas to air required for satisfactorily colouring matured citrus fruit was found to be from 1 in 1,500 to 1 in 3,000. One ounce of carbide will suffice for every 75 cubic ft. of "free" air space, i.e. after

making allowance for the volume occupied by the crates of fruit. Dunnage—strips of wood between the crates—is used when stacking them so as to ensure free air circulation. The fruits are exposed to the air-gas mixture for a period of 4 hours, at the end of which time the chamber is well aired for at least 2 hours. This is very necessary if the fruit is to be free from any taint. The procedure is repeated till the fruit is sufficiently coloured, the carbide being renewed at each refilling. This process is now being used commercially and is described by Prest [13]. Experiments carried out in this laboratory showed that grapefruit and oranges can be very satisfactorily coloured by the process. Matured grapefruit took from 3 to 5 days to colour. The fruit so coloured kept well and had no adverse flavour whatsoever. The effects of the gas on the ripening process of bananas have already been indicated [14]. A point of interest about acetylene gas observed by Denny [3] is that the pure gas does not hasten fruit colouration, while the commercially prepared gas does so.

COSTS

The cost of the ethylene process is very small. In the United States it works out at from 25 cents to a dollar for a carload of 300 to 360 boxes of fruit. For local conditions the cost will not exceed a small fraction of a cent per fruit. The cost of colouring citrus by acetylene gas worked out at one-seventh of a penny per case of oranges in Australia.

ADVANTAGES AND DISADVANTAGES OF ARTIFICIAL COLOURING AND RIPENING

It may be well to discuss the advantages and disadvantages of artificial colouring and ripening. For certain fruit, (e.g. lemons), the adoption of artificial curing as already explained, is essential. Colour is no indication of maturity in citrus, and for such varieties as colour poorly when mature the advantages of the process are patent and colouring becomes quite legitimate. The trade, rightly or wrongly, has discouraged the sale of green citrus fruit and purchasers decidedly prefer well-coloured fruit. There is no reason, therefore, why fruit desirable in every other way should not be coloured, especially as the cost is insignificant and the profits enhanced. A second advantage of artificial colouring is that fruit can be coloured or ripened uniformly for the market. This uniform ripening is also very desirable for canning purposes. The process being essentially one which accelerates ripening, the possibilities in regard to the early or out of season market are apparent, especially if used in conjunction with cold storage. A further advantage of the ethylene

process is that it is harmless when compared with the dangerous stove method of "sweating" fruit. The treatment is also likely to result in fruit of better eating quality. This does not hold in the case of certain citrus species but, on the whole, does apply to a large extent to a number of other varieties of fruit. As to the improved keeping quality of treated fruit, especially citrus fruit, there is practically entire agreement.

The great disadvantage of the artificial colouring process in so far as it applies to oranges and grapefruit is that immature fruit, unfit for consumption, may be coloured artificially and sold as sound fruit. But immature coloured fruit can always be discovered. It never assumes the rich colour of fully matured fruit. The difficulty has been overcome in practically all citrus-producing countries by the enforcement of Food Laws which declare that no citrus fruit can be sold for consumption unless it passes a certain chemical standard. Thus in South Africa the minimum total solids/acid ratio of ripe oranges should be not less than 6 to 1 [15], while in Florida this is 7 to 1 [16]. If an export citrus trade from Ceylon should develop to any extent, it would be necessary to introduce some such tests for local varieties of citrus.

PRACTICAL DETAILS

A few practical points in regard to the colouring and artificial ripening of local varieties of fruit by the ethylene process will not be without interest to intended users. A great deal of practical information is supplied by Harvey [1], but the brochure by the Carbide and Carbon Chemical Corporation, New York, entitled "Ethylene for Colouring Matured fruits and Vegetables" will be found very useful. The information supplied below has been obtained as a result of experiments carried out locally.

Grapefruit.—The fruit should be well washed and wiped with soft cloth before it is put into the colouring chamber. A maximum gas concentration of 1 to 1,000 of air and frequent changes of gas are advised if the retention of the buttons is desired. Normally two exposures a day of about 8 to 10 hours each will suffice. The thorough airing of the chamber for one hour at least between successive charges of gas is essential. When fruit is well matured it colours very well, a total period of two to four days, depending on the degree of maturity of the fruit, being required. The fruit keeps very well after colouring.

Oranges.—Only the very best quality and well matured oranges of the local variety should be coloured. Even with these the rich orange colour is difficult to secure. The same remarks as to the treatment of grapefruit apply with regard to this fruit. From 4 to 5 days will be required for satisfactory colouring. A little water placed in an open pan is desirable if the humidity is low to prevent the wilting of the fruit.

Lemons.—The best curing temperature for lemons is about 65°F. Frequent ventilation is essential. The humidity should be about 80 per cent. Lemons take five to six days onwards to colour satisfactorily. Colouring to full depth is not required, as this will be attained in ordinary storage after removal from the chamber.

Plantains.—The concentration of ethylene gas recommended for ripening plantains is 1 to 1,000 of air. The optimum temperature is about 70°F. Higher temperatures lead to mould development. To prevent the shrinking of the skin, the humidity must be retained at 90 per cent. in the early stages of the process by placing an open pan of water in the chamber. As the fruit ripens the humidity should be diminished to about 75 per cent. From two to three days' treatment will be required for ripening. The local *anamalu* ripens and colours quite evenly with careful treatment.

Mangoes.—Too high a concentration of gas is not desirable. A concentration of 1 in 2,000 will suffice. The humidity must be neither too high nor too low. The treatment increases the rate of colouring of those varieties which colour normally, e.g. the local Bombay mango, and of the ripening of all varieties.

Pineapples.—This fruit has been exposed to an ethylene-air mixture of 1 to 1,000 with very favourable results so far as appearance, rate of maturity and quality of fruit go. Three to four days are required for ripening mature fruit.

Tomatoes.—Concentrations of ethylene less than 1 in 1,000 have given good results with this fruit. The time of ripening varies entirely with the degree of maturity and variety of the fruit. From three to six days were found necessary for satisfactory results. Temperatures of 65° to 75° F. are the best, higher temperatures rendering the fruit susceptible to mould attack. A fairly high humidity is necessary to prevent shrinkage of the fruit.

Sapodillas.—The astringency of hard, well-matured fruit was entirely removed in two or three days by treatment with ethylene gas in concentrations of 1 in 1,000. Normal air temperatures and humidity were worked with.

CONCLUSION

In conclusion, it may be stated that a few enterprising fruit-growers in Ceylon have already taken advantage of this comparatively simple process of artificial colouration and ripening of fruit to market their produce in a far more attractive condition than in the past, with consequent increased sales and monetary returns. This has been especially so with some of the citrus varieties. But pineapples and plantains have also been placed on the market after treatment with ethylene gas with gratifying results. The process offers great possibilities in the hands of reliable growers for a successful trade in some of the citrus varieties, particularly grapefruit.

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MYCOLOGICAL NOTES (23)

THE OIL TREATMENT OF PLANTAIN DISEASES

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THE two important diseases of plantains in Ceylon are bunchy top disease, which has been known here since 1913, and Panama or wilt disease, which has been recorded in Ceylon only since 1931. Both of these diseases have proved themselves capable of causing extensive losses both in Ceylon and elsewhere and the need for the adoption of rigorous control measures has been widely felt. The diseases have been introduced into districts hitherto free from them by means of infected suckers used for planting up new areas. It has been made obvious therefore that, in order to stamp out the diseases, the first essential is to prevent the possibility of their further dissemination by the complete destruction of all plants which are affected by one or the other of the diseases. To this end, it has been the policy of the Department of Agriculture to recommend that, whenever the symptoms of either bunchy top disease or Panama disease are observed on a plantain sucker, the whole clump or stool containing that sucker should be uprooted *in toto* and destroyed by fire or by some other method. This process is laborious and difficult of execution. It is difficult to ensure the complete removal of the plantain clump, the pseudo-stems of the suckers are soft and sappy and difficult to destroy by fire and with Panama disease it has been suggested that the disturbance of the soil tends to increase the activity of the parasite and to hasten the infection of surrounding plants.

In Jamaica, where the presence of Panama disease has been a menace to the banana industry, the need for some better method of treating diseased bananas was realised some years ago. It was felt that the treatment of the disease would be facilitated if some chemical could be found which would kill the banana plant *in situ* without the necessity for digging up the roots and thus disturbing the infected soil. Hansford started experiments with a number of chemicals in 1923 but in 1926 [1]

he stated that "none of these treatments was found efficient, and none could be relied on for general use by our inspectors in treating the disease. In fact, it would appear that the only way of killing a banana plant is to dig it up completely".

Hansford's work was followed up in 1930 by Smith [2] who found that the application of kerosene was successful if the plantains were cut back to within a few inches of soil level before treatment. He obtained almost complete success with quantities varying from one pint of Kerosene on young plants to three pints on fairly large clumps or "ratoons". Kerosene fulfils every requirement except one. It is easily obtainable, easy and safe to use and is efficient, but the cost of using it on a commercial scale in big plantations would be prohibitive. Extending his experiments, Smith found that he obtained equally successful results with Heavy Gas Oil, which was much cheaper than Kerosene. Consequent on his work, legislation was introduced into Jamaica embodying treatment of diseased banana plants by oil as an alternative to digging them up and destroying them by fire. The oil method has been adopted with success and it has been found that the cost of treatment with oil is less than that of uprooting and burning.

The success of this form of treatment of diseased plantains has led to the carrying out in Ceylon of experiments with oils. In the first series the following oils were tested:

	Specific Gravity	Closed Flash-point
Persian Fuel Oil ...	0·935	222° F.
Persian Diesel Oil ...	0·895	203° F.
Tarakan Fuel Oil ...	0·938	185° F.

The plantain clumps used in the experiments were $2\frac{1}{2}$-3 years old, each clump containing a number of suckers. All vegetable débris, grass and weeds around the base of the clumps were first removed and the suckers were cut down with a knife, each sucker being cut off clean at about four inches above the surface of the soil. The oil was applied in small quantity to the surface of the suckers and well sprinkled immediately round the suckers. An attempt was made to give an even distribution of the oil over the whole clump. It was found that it did not matter if the soil was wet at the time of application and it so happened that most of the applications made in the course of the experiments were on wet soils.

In the first trial the effect of the application of two pints and four pints of each oil was tested, four clumps being used for each treatment. The only treatment which gave any promise was that in which four pints of Tarakan fuel was used. The other two oils were therefore discarded and a further trial was made with Tarakan fuel, using an application of four pints per clump for one series, and of six for the other. The application of six pints per clump was found to kill a large proportion of the plants but one or two small suckers developed from most of the clumps, which indicated that penetration and killing of the rhizomes was not complete. To use more oil meant that the cost would be too great for general use. (Tarakan fuel oil costs 25 cents per gallon f.o.r. Colombo). It was decided to test another oil, which although more expensive, might prove to be more economical in use.

Field trials were made with a Gas Oil (Specific Gravity 0·864; Closed Flashpoint 170/180°F.). This oil gave uniformly satisfactory results. One pint of oil was found to be sufficient to kill small plants while two pints of oil were found to be sufficient to kill moderately large clumps ($2\frac{1}{2}$ to 3 years old). Small suckers developed from some of the treated plants but these suckers were easily removed by hand. The results are summarised below:

No. of Clumps treated	Treatment	Average No. of suckers at time of treatment	No. of suckers one month after treatment
4	1 pint oil	2	1 sucker in one clump only: others killed
4	$1\frac{1}{2}$ pints oil	4	all dead
4	2 pints oil	6	1 sucker in each of two clumps: others killed
4	control	5	21 suckers in all: (4, 6, 4, 7 respectively)

In the control plants, the suckers were cut down in the same way as the others but no oil was applied. In counting suckers in the original clumps, very small suckers or "peepers" were disregarded since some were injured and removed in clearing

away the weeds etc. and a fair count was impossible. Suckers of all sizes were counted at the end of the experiment. The two clumps from which suckers grew after an application of two pints of oil were spread out and covered an unusually large area of ground. The suckers which developed from these clumps were easily removed by hand.

Further casual trials with the oil have been made in treating diseased clumps in the laboratory compound. It appears probable that diseased plantains will be more easily killed than the healthy ones on which the experiments were carried out.

Treated plants have been dug up and the effects of the oil noted. The outside of the rhizomes becomes discoloured from the action of the oil and this is followed by a rapid decay of the whole root system. Sufficient time has not yet elapsed since the experiments for a test to be made of the effect of the treatment on future plant growth. Smith (*loc. cit.*) carried out experiments and the following is an extract from his paper on the subject:

> "Before the method could be put into general practice it was necessary to determine whether the oils which it was proposed to put into general use would have any effect upon future plant growth. Accordingly a number of the sites of the experiments were planted with a variety of crops, care being taken that the actual places where oil had been applied were planted. The following plants were used: Grapefruit seedlings about nine months old, sweet potato cuttings and cabbage plants, and ultimately some 20 spots were replanted with bananas. These replantings were made from two to six months after the application of oil and with one exception, a grapefruit plant in which the cause of death was doubtful, all grew quite healthy and the bananas are now fruiting normally."

The cost of the oil used in the successful experiments and recommended for general use is 45 cents per gallon f.o.r. Colombo. The oil is known as Plantain Disease Oil and is sold by Messrs. The Shell Company of Ceylon, Ltd. Estimating that the average quantity of the oil used for treating diseased plantain clumps is $1\frac{1}{2}$ pints per clump, the cost of oil for treating diseased plantains is nine to ten cents per clump. No figures are

available of the cost of uprooting and destroying diseased plantains, but it is doubtful if the cost is less than that quoted above. The oil treatment has the merits of being simple, easily supervised and cheap.

SUMMARY

1. The treatment recommended in the past for the two serious diseases of plantains in Ceylon, *i.e.* bunchy top disease and Panama or wilt disease has been the uprooting and destroying by fire of all plantain clumps in which either of the diseases has appeared. It has been found difficult to carry out this treatment efficiently owing to the habit of growth of the plantain.

2. In Jamaica a satisfactory treatment of diseased banana clumps with a Heavy Gas Oil has been evolved.

3. Experiments are described above in which different oils have been tested in Ceylon, and a satisfactory and cheap oil has been discovered.

4. The treatment consists of cutting down diseased plants to within four inches of the ground level and of pouring on and around them one to two pints of the specified oil. The oil penetrates into the soil and kills the underground portions of the plantains. The cost of oil used in the treatment is estimated at approximately ten cents per plantain clump or stool.

I wish to record my appreciation of the courteous co-operation of the representatives of Messrs. The Shell Company of Ceylon, Ltd.

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A NOTE ON THE CULTIVATION OF THE CAULIFLOWER IN THE LOW-COUNTRY DISTRICTS OF CEYLON

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INTRODUCTION

THE cultivation of the cauliflower in Ceylon has hitherto been restricted to the higher elevations of about 4,000 to 6,000 feet above sea-level, where under relatively low conditions of temperature, the formation of heads in this introduced vegetable has proved successful. At low elevations, however, cauliflowers do not usually thrive and hence they have been regarded as a crop only suited to areas where temperate conditions prevail.

As one of the prized English vegetables not commonly obtainable, cauliflowers are held in great esteem in Ceylon. There is always a demand for them in Colombo, where good prices can be realised, and if they can be grown satisfactorily in the low-country districts of Ceylon, and around the larger towns especially Colombo, the demand should increase, thus leading to a considerable development in the cultivation of this attractive and delicate vegetable.

Trials were recently carried out at low elevations in Ceylon with certain strains reported to be acclimatised in India. The results have so far been encouraging and indicate the possibilities of growing cauliflowers in the low-country market gardens of the Island.

DESCRIPTION

The cauliflower is an essentially temperate crop, being a cultivated variety of the wild species of cabbage (*Brassica oleracea*) found growing along the sea-shore in England and South and Western Europe. It is recorded as having originated as a mutant, like several of the other cultivated varieties, in which modifications of the various parts of the wild cabbage have

taken place as e.g. in the stem in knol-khol, in the foliage in borecole or kale and the axillary buds in Brussels sprouts. In the cauliflower the mutation was confined to the floral parts, the peduncles or flower stems becoming so enlarged and modified in size and appearance that they form a dense, white and tender mass with just the rudiments of the flowers themselves. This is the edible portion referred to as the head, subtended by a number of cabbage-like leaves. The inflorescence is, however, formed somewhat later after the head is ready to harvest, but many of its branches remain aborted.

There are several so-called varieties or races of this vegetable, differing in size, vigour, earliness, firmness of the heads and table qualities. The broccolis are a group distinguished by being hardier in cold countries and of a longer duration of growth. They are, therefore, grown as a winter crop in such countries. The cauliflowers themselves can be classed as early or late strains according to the time of flowering—the early taking about 90 to 100 days and the late strains about 100 to 130 days.

Many of the cultivated varieties of the wild cabbage have been grown quite successfully at the higher elevations in the Tropics. The cultivated cabbage is, however, the only variety that has been grown with any degree of success at low elevations in Ceylon and though it does not generally form a head it is cultivated for its crop of green leaves which grow loose and open. The cauliflower, on the other hand, is a more delicate crop to grow and even at high elevations while good vegetative growth may be produced, the head may sometimes fail to form for such causes as, perhaps a spell of unfavourable weather, the incorrect time of sowing or the planting of an unsuitable strain.

TRIALS

The trials with cauliflowers in the low-country were first carried out at Gampaha, during the 1932 south-west monsoon season, with an Indian strain, called Patna. It was reported to be an acclimatised strain suitable for cultivation at low elevations in India. The seeds were sown in nurseries and then transplanted in the open. The growth was remarkably good from the commencement and unexpectedly well-developed heads were formed.

The following north-east monsoon season the trials were repeated with the same strain at Gampaha, Mirigama and Colombo. The growth was again good and the formation of heads took place readily in most of the plants. In some cases,

however, while there was an excellent vegetative growth no heads were formed, but the plants in such plots were transplanted too late in the season.

The formation of heads in these areas situated almost at sea-level has not previously been recorded in Ceylon and the success obtained with the Patna strain was considered sufficiently striking to merit a preliminary note on this subject.

METHOD OF CULTIVATION

The seed should be sown in a nursery bed or box containing well-prepared, rich soil in an open sunny situation. It was found that unless the sowing is fairly thin, the seedlings that come up are too close and crowded, and resulted in the development of weak and drawn plants. It is, therefore, advisable first to sow the seed broadcast, as thinly as possible, and then transplant them after a week's growth to another bed or box. The soil in the nursery should be watered the previous night and after sowing in the morning the seed should be covered over with a thin layer of light, sifted soil and gently watered each day. Germination is very rapid, taking place almost the next day and in about two days' time the cotyledons make their appearance. When the seedlings are about two to three inches high they should be transplanted about three inches apart each way to a second seed bed or box. The nurseries should be allowed to receive a few hours' sunlight each day and kept lightly shaded for otherwise the plants become less robust and are more liable to attacks from insects when always shaded. After the plants have attained a height of about six to eight inches they should be transplanted in the open at a distance of two by two and a half feet in well-manured beds. Frequently transplanted plants show better growth and it is therefore advisable to carry out this operation at least twice. After transplanting, the beds should be watered in the evening.

The soil should be a light loam capable of easy drainage. It is essential that it should be well-manured and there should be no check in the growth of the plants at any stage, otherwise they are liable to produce only leaves and form no heads. A few weeks before planting out well-rotted cattle manure should be spread over the beds and the soil should then be dug over so as to incorporate the manure thoroughly with it. As a top dressing a dose of liquid manure or a suitable fertiliser may be applied. Cattle manure when used should be well-rotted, then spread around each plant and covered over with a layer of soil.

Frequent intercultivation is necessary; the soil should be kept constantly hoed and the plants should be earthed up. The beds should be kept quite clean so as to prevent insect attacks.

As soon as the heads begin to form, the surrounding leaves should be gathered over and tied around them or the leaf stalks should be partially broken and bent over so as to exclude strong sunlight and thus increase the whiteness of the heads.

The nurseries for the south-west monsoon season are best prepared early in May and transplanting may be carried out after the heavy rains during the middle of June. For the north-east season the nurseries should be sown about the beginning of October and transplanting should be done towards the latter part of November after the heavy rains have passed.

An ounce of seed will produce about 2,000 to 3,000 plants and about four to six ounces will suffice for one acre.

PESTS AND DISEASES

Cauliflowers are very liable to the attacks of insect pests. There are several leaf-eating caterpillars some of which also burrow into the heads of this vegetable, thus rendering the attacked plants quite unsaleable. The beds should be kept very clean as stated before and only well-rotted cattle manure should be used and applied preferably a few weeks before transplanting. During the early stages of the growth of the plants they may with advantage be dusted with ash or better with a mixture of Paris Green and ash in the proportion of one part by weight of Paris Green to thirty-two parts of ash or one oz. to two lb. When plants with developing heads are found attacked by caterpillars they should immediately be pulled up and destroyed.

A disease that commonly attacks cauliflowers especially in market gardens around Nuwara Eliya is Clubroot or Finger and Toe caused by the fungus *Plasmodiophora brassicae*. The roots of affected plants become enlarged and knotty, and then decay, while the leaves turn yellow. Owing to the tendency of this disease to appear in acid soils it can be appreciably checked by the application of a heavy dressing of lime up to about 20 lb. for every 100 sq. feet before planting. The land should furthermore be well-drained as a high water content of the soil is necessary for infection. Other preventive measures to be taken are: the selection of healthy plants, the destruction of all diseased plants and rubbish and the rotation of crops by the planting of crops other than those of the cabbage family on the same land for a few years.

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE*

TO Sir Norman Lamont, the second baronet, is due the credit for having been the first to call attention to the need of an Agricultural College for the Colonies situated within the tropics.

In an article which appeared in the *Empire Review* as far back as 1902 he, then Mr. Lamont, sketched out the form which such a college might assume.(1) Read today, his suggestions seem to have been almost prophetic. He considered that the Imperial Department of Agriculture, which had been founded by Mr. Joseph Chamberlain four years before, would form "an excellent nucleus for the College," which must be of university standing; that candidates for admission, who should not be less than seventeen years of age, should be required to pass a searching examination before admission and again at the close of each year's session, which should be of nine months' duration; and that there should be attached to the College an instructional sugar factory—all of which has come to pass. Developing his theme in 1913 at a meeting held under the auspices of the Liberal Colonial Club at the residence of Sir Robert Perks, M.P., he definitely suggested that the College should be in Trinidad and that the headquarters of the Imperial Department should be transferred to that Island. He also stressed the great importance of research.

Another protagonist of the movement was Professor J. B. (now Sir John) Farmer, who declared in season and out of season that the College must not be a mere local institution but must have a real scientific and research outlook and very high ideals.

It was not until after the War that the proposals for the establishment of a Tropical Agricultural College emerged from the discussion stage. Sir Francis Watts has already related in these pages how in accordance with the recommendations of a Committee set up in 1919 by Viscount Milner, then Secretary of State for the Colonies, with that eminent biologist and man of affairs, Sir Arthur Shipley as Chairman, the West Indian Agricultural College was founded in Trinidad in 1921 and was thrown open to students in the following year.

Pending the presentation of a petition to the King for a Royal Charter, the College was incorporated as a company "limited by guarantee." Sir Arthur Shipley was Chairman and Sir David Prain, then still the Director of the Royal Botanic Gardens, Kew, Vice-Chairman. Sir Francis Watts, the Commissioner of Agriculture for the West Indies, was the first Principal, and he and the members of his scientific staff, who, with the headquarters of the Imperial Department of Agriculture, were transferred from Barbados to Trinidad, form the Academic Board.

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* By Sir Algernon Aspinall, C.M.G., C.B.E., B.A., Secretary of the Tropical Agricultural College Committee, in *The Empire Cotton Growing Review*, Vol. X. No. 3, July, 1933.

(1) "The West Indies: A Warning and a Way", by Norman Lamont.—*The Empire Review*, Vol. IV, No. 19, August, 1902.

In selecting Trinidad as the site of the College the Tropical Agricultural College Committee were influenced by several advantages offered by that Island. Foremost among these were complete immunity from hurricanes or cyclones, a wide variety of tropical products, and accessibility from the other West Indian Islands and British Guiana as well as from England. There were also Trinidad's generous offers of land at St. Augustine, and a handsome contribution of £50,000 for building, to provide which the planters actually asked that they might be taxed. It should be recorded that, after the Committee had approved their Report, Jamaica made a similar offer conditional upon the Imperial Department being removed to that Island.

It is still sometimes asked why the College was located in the West Indies and why not in Ceylon or Malaya, for example. The reply is that, as Lord Milner and Sir Arthur Shipley used to say, the College *had* to be placed *somewhere*, and experience has shown that its geographical position has not deterred students from entering it from Ceylon and even the distant Seychelles.

Prince Albert Victor and Prince George, now King George V., in their narrative of their cruise in H.M.S. *Bacchante* (1879-1882), after describing a visit they paid to the Maracas Fall in Trinidad, wrote: "On returning the views appeared finer than they did on going up . . . . . just above San Josef . . . from the front of the Church . . . the plain looked in the low evening sunlight just like an English park with its grass, and large rounded trees standing here and there in the paddocks." Just over forty years later that park-like plain was selected by Mr. W. G. Freeman, then Director of Agriculture of Trinidad and Tobago, as the ideal site for the new College. On it have now risen residences, hostels, and laboratories grouped round about a stately building which accommodates the administration department and the library, while unobstrusively tucked away in one corner are the sugar factory, power house, gas plant, and low temperature station. The Principal occupies the old "great-house" of St. Augustine estate, and scrupulous care has been taken to preserve the amenities of the site. The condition of the buildings, roads, lawns, and hedges is an object lesson of how real estate should be tended in the tropics.

Although the College began its existence as a West Indian institution, provision was made at the very outset for post-graduate study and research, and "refresher" courses for Agricultural Officers, besides a three years' Diploma course. The Governing Body in their first Report declared that they had had constantly in view the desirability of establishing the College on the broadest Imperial basis so that it might provide for the needs not only of the British West Indian Colonies and British Guiana, but also of the tropical Colonies of the Empire generally. In 1923 in order to emphasise the Imperial nature of the undertaking, they changed the name of the College to "The Imperial College of Tropical Agriculture." Under that significant title it was incorporated by Royal Charter in 1926 receiving in the following year the gracious patronage of the King.

Meanwhile Sir Francis Watts, who had done so much towards founding the College had retired in 1924 and had been succeeded by Dr. Hugh Martin Leake, Principal of the Agricultural College at Cawnpore, whose régime was marked by much valuable constructive work, including the planning of roads and additional buildings and an expansion of the curriculum.

In the first academic year there were eleven Diploma students and two post-graduates on the register. At the close of the 1924 the corresponding numbers were eighteen and fourteen. They have since steadily increased, until this year there were fifty-two students in residence, of whom twenty-four were taking the Diploma course, twenty-five the post-graduate course, and three special courses.

A turning-point in the history of the College was the appointment of a Committee in 1924 by Mr. J. H. Thomas, M.P. then Secretary of State for the Colonies, with Viscount Milner as Chairman, to enquire into and report upon the recruitment and the training of officers for the Agricultural Departments and of the non-self-governing Dependencies. Since the War there had been a definite awakening to the potentialities of the Colonies, with their area of upwards of 2,000,000 square miles and their vast population of 50,000,000 souls, as a source of supply of essential foodstuffs and raw materials, and as a market for manufactured goods. Between 1905 and 1925 trade between the United Kingdom and the Colonies had been nearly quadrupled, but for the further development of agriculture scientific assistance were lacking, and there was grave difficulty in finding suitable candidates for the Colonial agricultural services.

Recognizing at once the seriousness of the shortage of botanists, entomologists, and mycologists, the Committee presented to the Secretary of State for the Colonies in March, 1925, a preliminary report in which they outlined a scheme for the provision of post-graduate scholarships to be granted annually to suitable applicants in order to create a pool from which the needs of the various Colonial Agricultural Departments might be met from year to year. They recommended that these scholarships should normally be granted for two years, the first to be spent at institutions in this country and the second usually at the Imperial College of Tropical Agriculture, in order to give the scholars a practical introduction to systems of tropical agriculture on the spot.

These recommendations were approved by a great majority of the Colonial Governments invited to co-operate, and the Imperial Government consented to provide, over an experimental period of ten years, grants equivalent to one-third of the total contributions available. It is noteworthy, and indeed an historic fact, that in adopting this system the Government was following the lead of the Empire Cotton Growing Corporation, which having similarly experienced difficulty in recruiting suitable officers for its research and development work, first sent out selected candidates for training at the Imperial College of Tropical Agriculture in 1922. Fifty-five students of the Corporation have already passed through the College and are now working in such widely scattered parts of the Empire as the Union of South Africa, Northern Rhodesia, Southern Rhodesia, Nyasaland, Uganda, Nigeria, the Gold Coast, the Sudan, Tanganyika, Trinidad, Jamaica and Ceylon.

It was not until three years later that the first Colonial Office students entered the College. No fewer than 120 have now passed through it and most of them have taken up appointments in the Colonial agricultural services. Never before can the report of a Committee have been more promptly or successfully implemented.

Since the Cotton Research Station was opened by the Empire Cotton Growing Corporation in 1926 it has been closely associated with the College. Dr. S. C. Harland and Mr. T. G. Mason, its two executive officers, had been for a short time members of the College Staff. Its research laboratories are within a stone's throw of those of St. Augustine and are provided with gas and electricity from the College plant. The liaison became closer in 1927, when on Dr. Leake's retirement Mr. Geoffrey Evans, who had been Director of Cotton Culture in Queensland under the Corporation since 1923, was appointed Principal, and, after the lamented passing of Sir Arthur Shipley, whose last illness was undoubtedly aggravated by anxiety and worry over the finances of the College, Sir James Currie, Director of the Corporation, became Chairman of the Governing Body of the Imperial College.

All that is necessary in respect of investigations into cotton is performed at the Cotton Research Station, and long-range research at the College is confined to cacao, sugar-cane, bananas, and citrus. Cacao research is financed by some of the leading manufacturers and the cacao-growing Colonies, and, for the present at any rate, banana research by the Empire Marketing Board, which provided funds for the erection and equipment of a modern low temperature plant. Side by side with this research, experiment work is being carried on with soils and fertilizers with the support of Imperial Chemical Industries, and each of the principal departments of the College—namely, those devoted to agriculture, botany and genetics, chemistry and soil science, economics, entomology, and mycology and bacteriology—is conscientiously working on various problems with the solution of which they are concerned. Each with one exception is under the charge of a professor (in the case of entomology a senior lecturer), who is assisted by a lecturer. Mention must also be made of the Department of Sanitation and Hygiene, the officer in charge of which imparts to the students a rudimentary knowledge of health in the tropics which not only proves of great value to the men themselves but also to the labourers under their control in the various parts of the world in which they are posted.

As Professor (now Sir John) Farmer has pointed out, there had existed a gap, largely unbridged, between the university at home and the work that awaited the agricultural officer in his district, where the conditions that embraced his problems and affected their solution were so widely different from those within the range of his previous experience. The College enables this hiatus to be short-circuited, and it is now possible for a man in a few months to build effectively on his previous knowledge of principles. In short, he is now in a position to obtain easily and under exceptionally favourable conditions just that kind of wide outlook over, and reasonably intimate familiarity with, the material and environment of his prospective problems so necessary for ultimately attacking them with good prospects of success. Then, to quote Sir Arthur Shipley, men of science are slowly but surely gaining control over the devastating forces of nature. To train them for the conquest they must have education. They must be taught what advances have been made by their predecessors, and

what advances are being made by their contemporaries. Above all they must learn to observe accurately and to record faithfully what they have observed. Such training cannot be carried out at home and alone. It needs an institution like the Imperial College with its library, its laboratories, its experiment fields, and its staff of skilled professors and lecturers.

The College was visited by Mr. F. L. Engledow, now Drapers' Professor of Agriculture at Cambridge University, in 1929, at the request of the Empire Marketing Board, and in 1932 by Mr. F. A. Stockdale, the Agricultural Adviser to the Secretary of State for the Colonies. Both were favourably impressed by what they saw, and the College received also the commendation of the Colonial Office Conference which met in London in 1930. A Committee of the Conference, of which Sir Herbert Stanley, then Governor of Ceylon, was Chairman, recorded their deep appreciation of the work being carried out, and placed on record their recognition of the importance of the Imperial College as the centre for post-graduate training in tropical agriculture for the agricultural services of the Colonial Empire. In their report on the organization of a unified Colonial Agricultural Service they recommended that membership of the service should be confined in future to candidates who had received not less than two years' training, of which in the case of Colonial Agricultural Scholars one year would normally be spent in Trinidad. It is a matter for regret that, owing to circumstances arising from the world trade depression, the unified Colonial Agricultural Service, which had also been so strongly advocated in 1927 by the Committee of which the late Lord Lovat was Chairman, has so far failed to materialize; but when the proposals in this connection are revised the Imperial College should be in a position to play its part in making them effective. To revert to the Committee of the Conference. They finally expressed the hope that every Government might find it possible to give substantial financial assistance to the College and that "in any instance where circumstances should preclude this being done, at the very least an annual contribution of a nominal amount will be forthcoming in recognition of the importance of the College in the development of Colonial Agriculture". Approval of the Committee's report was recorded by the Conference at a plenary meeting held in 1930, in the following minute: "In particular the Conference recognizes the importance of the Imperial College of Tropical Agriculture as a centre for post-graduate training in tropical agriculture for the Agricultural Services of the Colonial Empire. It recommends that those Colonial Governments which do not at present contribute towards its maintenance should be invited to give some financial assistance to the College as soon as a reliable forecast can be given as to its needs for the next five years." Then came the economic depression, and so acute was the financial crisis that the Colonial Office declined to invite the non-contributing Colonies to make even token contributions towards the maintenance of the College, whose staff is so ceaselessly working in the interests of the tropical parts of the Empire.

The question of finance has been a constant source of anxiety to the Governing Body. At the start contributions of one-half of one per cent. of their revenue made by the West Indian Colonies (Jamaica excepted) towards the cost of maintenance were supplemented by a grant-in-aid of £15,000, spread over five years, from His Majesty's Government. The British Cotton Growing Association contributed £500 in the first year and has given the

same amount anuually ever since. In the second year the Empire Cotton Growing Corporation made the first of a series of annual grants of £500 which are still being maintained, and in 1926 it generously contributed jointly with the Empire Marketing Board and in equal moieties a capital sum of £42,000 of which £10,000 was earmarked to meet existing liabilities and the balance for new buildings and equipment. This brought the total of a special fund which Viscount Milner, and after his death Viscount Burnham, consented to raise to £87,872. The Empire Marketing Board has also been a generous benefactor of the College. From 1926-27 onwards it provided annual contributions at first to meet deficiencies, and latterly in the form of block grants, but with increasing demands made upon the College, and the rapid development of its activities, the Governing Body found it impossible to balance the annual budget. In 1931 they were promised a block grant of £16,000 a year for five years from the Empire Marketing Fund, but when the world trade depression became acute the grant was cut to £14,400 and the prospects of its continuance appeared doubtful. A deputation, therefore, waited on Sir Philip Cunliffe-Lister on December 10, 1931, to explain to him the gravity of the situation. It was introduced by the Earl of Derby and included representatives of Cambridge University, the Empire Cotton Growing Corporation and the British Cotton Growing Association, besides the Governing Body, who declared that the difficulty of financing the College had become so acute as to threaten to interfere with the education and research proceeding at it. As a result the Empire Marketing Board undertook to provide an annual block maintenance grant of not less than £14,400 and not more than £16,000, according to the strength of its financial position, for each of the four years 1933 to 1936. But now the Empire Marketing Board has been thrown into the melting pot. The uncertainty is therefore greater than ever, and it can never be completely removed until the Imperial College of Tropical Agriculture has behind it a substantial endowment fund, for the creation of which there is pressing need. In 1932 the Governing Body received a welcome contribution of £32,000 towards such a fund from the Carnegie Corporation, and it will be a sad reflection on British enterprise if it is not supplemented by similar gifts from wealthy firms and individuals resident in this country and in the Dominions and Colonies, whose imagination must surely be stirred by the achievements of the College, past students of which are now promoting the development of agriculture on scientific lines throughout our far-flung Empire.

PRACTICAL SEED SELECTION OF COCONUTS*

IN the past the selection of seed for the planting of the main commercial areas of tall coconuts in Malaya appears to have been carried out on what, at the best, must be termed haphazard lines. This grants that, in most cases, planters have done their utmost with existing facilities to obtain the best planting material on offer.

In no branch of agriculture is good seed expensive, betimes good or bad, and this is particularly the case with perennial crops with a long economic life—coconuts for example which normally remain profitable for a period of 30 to 60 years. In a crop of this nature planting is done once and for all, the use of poor material cannot be rectified in the following year as is the case with annual crops. The planter must stand upon the seed he provides in the first instance, therefore the expenditure of a few dollars more per acre on the best possible material is of little moment. Expressed in terms of cash one looks upon the difference between seed cost of $5 and $25 per acre on a 1,000 acre estate as vast, but if by provision of improved seed, yields can be obtained only 10 per cent. above average, say from 10 to 11 piculs of copra per acre, the cost plus interest is fully recouped in 7 or 8 years—less than one-quarter of the economic life of the palm—even with copra at $5 per picul.

Three methods of seed selection appear to have been used on the European owned coconut areas of Malaya.

(1) In the older (pre-1,900) plantings, by purchase from any mature estates or kampongs which had some reputation for yields and which were so situated as to afford reasonably cheap transport.

(2) By mass collection from known high yielding estates or areas.

(3) In a few cases from selected heavy cropping palms in known high yielding areas.

Each method marks a definite step forward but it cannot be said that great progress has been made. It cannot be denied that in respect of this problem the coconut industry lags behind most other large scale tropical products. Rubber, a much newer commercial agricultural proposition, has made enormous strides during the past 10 to 12 years, whereas coconuts have practically nothing to record. The reason for this is undoubtedly the time involved in evolving and proving a pure strain—probably two generations or about 25 years. There is unfortunately, no short cut by vegetative propagation as in the case of rubber, but as coconuts have been established as a commercial proposition for upwards of thirty years in Malaya, the indusry should by now be far ahead of where it actually is, and it must be admitted that very little energy has been applied to this most important yield factor.

* By A. C. Smith, in *The Malayan Agricultural Journal* Vol. XXI, No. 6, June, 1933.

Of the methods enumerated above, (2) is that most frequently used but at best it can only be expected to provide plants which will return good average yields. Examination of any high yielding area will establish the fact that the variation in yield per palm is from 0 to over 120 nuts per annum, with more than 50 per cent. of palms below average.

(3) is an improvement upon (2) but in most cases selection is confined to palms carrying heavy heads of nuts without due regard to copra content. Even where selection is carried a step further to handling and opening nuts from such palms for inspection of meat content, the margin of error is very large. Detailed examination of ripe nuts from 47 palms, all with a wet meat content of over 600 grammes, showed a variation in meat thickness between 10·5 and 15·5 mm. with the main group lying between 12·5 and 13·5 mm. Inspection of two nuts of approximately equal size with meat thickness of 12·5 and 13·5 mm. will indicate the difficulty of judging meat content by casual observation, yet the difference is no less than 8 per cent. An increase or decrease of 1 mm., although it has a very large bearing upon copra yield, is almost impossible to detect by eye alone.

Very detailed examination of palms and their nuts for seed purposes is, although laborious, well within the capabilities of any planter, and it requires no scientific training or special plant. From the writer's experience 600-700 palms can be examined and possibles marked in two to two and a half hours, and this is about as much as should be atempted at any one time; it is very tiring and one's power of observation flags towards the end. Where an area of palms returning yields well above average is available on an estate, the advantages of taking seed from such an area for extensions or re-planting are manifest. The primary advantage is that environmental conditions are suitable, palms doing well on one part of an estate should do well elsewhere in the same area, assuming that there is no great difference in soil and drainage conditions. There is no guarantee that seed from high yielding palms on the free undulating soils of say Penang Island would do equally well on the flat alluvial clays of the Lower Perak District.

If seed is required for a small area, close selection is a simple matter, but, if a clearing no larger than 100 acres is to be planted, it will be necessary to scour a fairly wide area to obtain a sufficient quantity of the required standard. Seedlings are usually planted out fairly early in the rainy season, and to obtain sturdy plants of even growth at this time necessitates the laying down of seed for the whole area more or less simultaneously. There is undoubtedly a tendency towards economising in the number of seed nuts purchased or laid down, and in consequence one frequently notices that the last portion of a clearing contains a proportion of poor and weakly seedlings. The total seed laid down should not fall far short of 100 per cent. in excess of the number of plants required. For 100 acres planted 30 ft. × 30 ft. and, allowing for first supplying, 5,000 plants are required; 9,000 seed is none too many. With germination of 85 per cent. which is rarely exceeded, the margin is only some 2,500 plants, or in other words two in every three have to fulfil ideal conditions as regards growth. Using seed from palms yielding not less than 100 nuts per annum with a satisfactory copra content, not more than 35 suitable nuts will be obtained from each palm during the three heaviest cropping months. This necessitates not less than 250 selected parent palms, and as such palms, even in a very

high yielding area, only amount to 3 to 5 per cent. of the whole stand, it entails the examination of 6,000 to 7,000 palms, or an area of 120 to 150 acres. If planting can be spread over a whole year it should be possible to obtain an average of about 150 nuts per acre from the selected area, or sufficient to plant up rather more than 1½ acres per acre of the selected area.

No method of seed selection which has to contend with open pollination, and consequent hybridisation, can be described as ideal, but so far there is no available supply of seed coconuts of pure strain, at least not on the scale applicable to estate requirements when planting up large areas. Work of this nature is now being carried out by officers of the Department of Agriculture at the Klang Experimental Station, but it will be long before a pure line is evolved and proved, two generations of coconuts or about 25 years, and then in all probability seed will not be available in large quantities. Beyond the fact that under normal conditions the tall coconut rarely if ever "selfs", and that therefore all seed must be cross pollinated, little is known of its genetics and hereditary traits. The best that can be done is to commence with an area containing a large percentage of palms yielding well above average, the chances of fertilization from a high yielding parent being distinctly favourable. The methods adopted by the writer and described below should be the most satisfactory in the light of present knowledge and applicable on a commercial scale. Selection method (2) is fully complied with in that the area from which seed is taken returns yields far above average, and (3) is fulfilled by the close examination of individual palms, thus as far as possible ensuring good female stock.

Selected area. 80 acres.

Age. 27 years. Planted 1906.

Planting. 30 ft. × 30 ft. = 48 palms per acre.

Yields.—Average 13 years 1920-1932, 3,860 nuts per acre. Conversion approximately 235 nuts per picul copra = 16·3 piculs per acre. Actual stand of bearing palms 45·5 per acre = 82 nuts per palm.

Situation.—All mature areas within approximately half mile radius return average yields of 3,300 to 3,500 nuts per acre.

Soil.—Flat alluvial clay.

Total palms examined.—3,875. Vacancies, supplies and non-bearers 153, bearing palms 3,722.

Method of selection.—Only palms carrying 100 nuts or more are selected as possible parents, all ripe nuts are collected from such palms and one typical specimen is selected for examination and weighing of wet meat.

Details of Palms

Total examined	...	3,875
,, 100 nuts and over	...	690 = 17·8 per cent.
,, 50 nuts and under	...	1,109 = 28·6 ,,
Average of "100 nut" palms		117·23 nuts

Having thus arrived at exceptionally high yielding palms as regards number of nuts, the selected nut from each was then weighed for wet meat content. The following table gives the weight out-turns in grammes wet meat per nut.

Table I

Over 700 grammes	...	3 =	0·4 per cent.
600/700 ,,	...	47 =	6·8 ,,
500/600 ,,	...	191 =	27·7 ,,
400/500 ,,	...	307 =	44·5 ,,
300/400 ,,	...	128 =	18·6 ,,
Under 300 ,,	...	14 =	2·0 ,,
		690	100·0 per cent.

These figures necessarily refer only to the 690 selected palms. That there would have been nuts from the palms carrying under 100 nuts returning both larger and smaller wet meat yields cannot be doubted. They further emphasise that the proportion of really high grade palms in a very high yielding area is very small, and that mass seed collection from such areas is unsound. Only 241 palms of the 3,875 examined returned 100 nuts of 500 grammes or more wet meat, equal to 6 per cent. In any system of close selection one would never go below 500 grammes. The general yield of estate grade copra is 50 per cent. to 53 per cent. of the wet meat content of nuts dealt with. Taking the lower figure, the approximate number of nuts required per picul of copra from the several categories is therefore:

(453·59 grammes = 1 lb. 60,479 grammes = 1 picul = 133·33 lb.)

700 grammes	= 173 nuts per picul.
600 ,,	= 201 ,, ,, ,,
500 ,,	= 242 ,, ,, ,,
400 ,,	= 302 ,, ,, ,,
300 ,,	= 403 ,, ,, ,,

A small variation in size will be found in nuts from the same palm and even from the same bunch. One nut cannot therefore be taken as a definite determination but it is the best that can be done under normal estate conditions, and if care is taken in selection, is accurate within practical limits.

The selection of nuts on wet meat content merely denotes working to a standard, dependent almost entirely upon the area available for selection and the number of seed required. If a large clearing is to be planted up, it will probably be necessary to modify the standard; if a very small area, selection can be very close and high grade planting material can be secured. In the writer's case two small clearings totalling only 15 acres were planted with nothing under 575 gramme seed, but where nuts were supplied for a 50 acres clearing in one delivery the standard had to be scaled down to 500 grammes.

It is frequently asserted that nuts of pronounced ovoidal shape should not be used as seed. Details of shape of the whole 690 nuts were recorded and it was found that there was no practical difference in meat content between oval and round specimens. Neither did colour appear to have any

bearing upon the value of the nut. Red, yellow and green types all show more or less the same percentage of good and poor yielders and high and low meat contents.

Further points emerged when approximately 500 nuts from 66 palms, all over 575 grammes, were laid down in the nursery. Wide variations in germination and growth were to be expected and careful notes were kept of the behaviour of seed from each palm. These were of such interest that a second batch was laid down as a check. In almost every case the general characteristics of seed from the same mother palm were identical in both batches. The first lot was laid down in July and notes taken in November, after four months. The second batch was laid down in November and notes taken in February, also after four months. Weather conditions in each case were favourable to germination and growth. The following examples of results from the two batches may be taken as typical of the whole.

Palm No. 12. 631 gr. November 8 nuts. Germination 8=100 per cent.
All strong healthy plants.
February 8 nuts. Germination 7=87 per cent.
All strong even plants.

Palm No. 29. 588 gr. November 10 nuts. Germination 7=70 per cent.
Weak and irregular, only 2 good.
February 14 nuts. Germination 13=93 per cent.
Very slow and weak, only 4 fair.

Palm No. 37. 575 gr. November 10 nuts. Germination 10=100 per cent.
All strong even plants.
February 25 nuts. Germination 24=96 per cent.
All strong even plants.

Palm No. 51. 656 gr. November 14 nuts. Germination 9=65 per cent.
No good plants, irregular and poor.
February 9 nuts. Germination 1=11 per cent.
Useless.

Palm No. 88. 585 gr. November 10 nuts. Germination 10=100 per cent.
All poor plants with malformed shoots.
February 8 nuts. Germination 5=62 per cent.
Poor, all shoots malformed.

Palm No. 122. 575 gr. November 7 nuts. Germination 4=60 per cent.
Weak, irregular and poor.
February 10 nuts. Germination 6=60 per cent.
Weak, irregular and poor.

Palm No. 160. 630 gr. November 18 nuts. Germination 9=50 per cent.

All very poor plants.

February 8 nuts. Germination 2=25 per cent.

All very poor plants.

Palm No. 183. 588 gr. November 12 nuts. Germination 12=100 per cent.

Exceptionally strong even plants.

February 8 nuts. Germination 8=100 per cent.

Very good and even.

Palm No. 190. 594 gr. November 8 nuts. Germination 4=50 per cent.

Poor.

February 4 nuts. Germination 1=25 per cent.

Useless.

Palm No. 239. 605 gr. November 2 nuts. Germination 2=100 per cent.

Both malformed shoots.

February 12 nuts. Germination 10=83 per cent.

7 malformed shoots.

On the whole, the large nuts showed a small percentage of germination and less strong healthy plants than did those of more nearly average size. There was very little difference in total germination percentage between the two lots, and in each case almost exactly 60 per cent. good sturdy even plants were obtained after five and four and a half months respectively. This indicates that it is unsafe to lay down less than 80 per cent. to 90 per cent. seed in excess of actual requirements.

The data recorded in the foregoing shows that there is room for vast improvement in yields by careful seed selection provided that the female parental characteristics are transmitted in the majority of cases. As stated previously, little is known regarding this at present but at the worst one commences with female stock of high standard, and with the male parent also taken from a high yielding area, chances are greatly in favour of better yields than have hitherto been attained. Returns of over 15 piculs of copra per acre are now deemed almost phenomenal, yet with promiscuous seed supply a large area is capable of yielding over 16 piculs per acre for 13 years. This is undoubtedly due largely to environmental conditions but it indicates that potentialities are greatly in excess of standards hitherto accepted as high, if close seed selection is carried out in an area of this yielding capacity. Even if environment is rather less favourable, selection on these lines should outweigh this, and similar yields, which are much above average, should be obtainable from any area of good coconut land with reasonable drainage facilities and good cultivation. Under approximately similar environmental

conditions, with selection no closer than palms yielding 100 nuts per annum with a 550 grammes wet meat content, yields of over 20 piculs per acre should be attainable. (5,000 nuts per acre at 220 nuts per picul.) Of the 3,875 palms examined 123, or slightly over 3 per cent., reached this standard—1½ palms per acre. Any high yielding area,—3,500 nuts per acre or better—should return approximately similar figures, therefore, as noted earlier, each acre should be capable of providing seed for about 1½ acres new planting each year. This by no means exhausts potentialities. Odd palms consistently returning over 800 grammes wet meat are met with. One in particular has so far averaged over 900 grammes and yields 70 to 80 nuts per annum or half a picul of copra from a relatively low nut output. The largest nut handled gave over 1,100 grammes wet meat, which equals 100 nuts per picul.

CONCLUSIONS

(1) By seed selection it should be possible to increase copra output per acre to a figure considerably in excess of that now accepted as normal.

(2) Examination of possible parent palms must cover both number of nuts and copra yield per nut. Also, having obtained seed of the required standard it is necessary to study nursery results in view of the fact that certain palms persistently yield nuts of low germination percentage and poor growth characteristics. Seed from high yielding palms is useless if it refuses to germinate, or having done so, produces progeny unfit to plant.

(3) Close selection of seed calls for nothing which cannot be carried out in ordinary estate practice, and is a simple matter on estates which contain areas of high yielding palms.

(4) With the standard scaled down to 100 nuts of 500 grammes palms, under 20 piculs per acre, only 6 per cent. of palms in a given area are fit for selection as mother palms.

(5) In the light of (4) mass seed collection from the best known areas can only be termed crude and haphazard.

ACKNOWLEDGMENT

The writer is indebted to Dr. H. W. Jack, M.B.E., Economic Botanist, S.S. and F.M.S. for his lecture delivered at the Bagan Datoh Club on 2nd May 1929, subject "Improvement of the Coconut Crop by Selection".—(*Malayan Agricultural Journal,* Vol. XVIII, No. 1.) Although no references are made to this paper, it furnished the incentive which led to the initiation and execution of the work described in this article, and the present conclusions confirm many of the statements made in that publication.

TEA CULTIVATION IN TANGANYIKA*

MATTER of great interest to East Africa and to tea cultivators in general is contained in the *Report on Tea Cultivation in the Tanganyika Territory and its Development,* by Harold H. Mann, recently published on behalf of the Tanganyika Government by the Crown Agents for the Colonies, price 2s. 6d.

Mr. Mann was requested by the Secretary of State for the Colonies to investigate the suitability of certain areas in Tanganyika for the production of tea. During his stay in Africa he visited also the tea districts of Nyasaland, and this visit will be the subject of a separate report. Mr. Mann states that the possibilities of tea cultivation in certain parts of Tanganyika have apparently been under consideration for many years, even during the period of German occupation. In more recent times, cultivation has been undertaken seriously in the Usambaras and in various parts of the Southern Highlands, and there have been experiments in a few other centres. These attempts have been encouraged by Government.

Before dealing with the subject proper, the author comments upon the very restricted areas from which the world's tea supply is obtained, due to the exacting nature of climatic and other requirements. Until the 'thirties of the nineteenth century, production of tea on a commercial scale was carried on exclusively in China, and if volume of production be taken as a test, China would still probably head the list. As regards exports, however, in 1929 China was responsible for only 8·1 per cent. of the world total, the other exporters being India, 42·2 per cent.; Ceylon, 27·9 per cent.; Java and Sumatra, 17·9 per cent.; Japan and Formosa, 3·7 per cent.; and Nyasaland, 0·2 per cent.

THE ESSENTIALS FOR TEA-GROWING

Points which have to be considered in judging of the suitability of any area for extensive tea developments are as follows:

(a) Climate, especially amount and distribution of the rainfall.

(b) Soil, especially as regards depth, character of sub-soil, presence or absence of lime, and reaction.

(c) Local conditions, such as the flat, hilly or broken character of the country, and similar questions.

(d) Labour, as regards amount, suitability and cost.

(e) Cost of transport to the sea, and also to the final market or local consuming centres.

(f) Probable quality of tea that will be produced.

* From *The Crown Colonist*, July 1933.

These requirements were considered by the author in regard to six different areas which he visited in Tanganyika, and as a result of his visits he states that he is able to recommend only three of these areas for "the pushing of tea cultivation under present conditions." These three areas are the Usambara Mountains, in the portion which possesses a heavy rainfall and which consists chiefly of the Eastern Usambaras and a small portion of the Eastern extension of the Western Usambaras; the Mufindi area of the Iringa Province; the Rungwe district, so far as concerns that portion lying towards Lake Nyasa at an altitude below 4,500 ft.

THREE TANGANYIKA AREAS

Of these areas, undoubtedly the best from most points of view is the first named; it is doubtful whether there is any area at present available in the world possessing more advantages than the Eastern portion of the Usambara Mountains. The only natural difficulties to be contended with in this area are the broken nature of the country and the lack of local labour. In the Mufindi area, although the available land is limited, and most of it already alienated, natural conditions are very good indeed, except that the elevation is great, and the yield per acre would be relatively small. The Rungwe area offers the best conditions for tea growing except in the Usambara Mountains, and labour is a good deal cheaper.

Government has so far taken little action to encourage tea-growing on a commercial scale, except by allowing alienation of suitable land and by supplying high-quality seed in the three areas mentioned. With regard to the alienation of land, it is pointed out that in no case has there been any alienation specifically for tea. Those who have taken up land and are now growing tea have, as a rule, obtained the land with other products in view, notably coffee. The result has been that the areas alienated, and the unit area for plantation, have been determined with a view to coffee and not tea cultivation. But conditions of success for the two crops are very different. A coffee estate may be small, and demands quite a small amount of labour, while manufacture of the berries is quite a simple operation. On the other hand, a tea estate, complete with factory, can, under modern conditions, be run with success only if it covers an extensive area. It requires a large and constant supply of workers and expensive manufacturing machinery used with high technical and engineering skill.

SYSTEMS OF LAND ALIENATION

The author deals with three possible systems of land alienation for purposes of tea growing. The first is the system of granting large areas to individuals or companies possessing financial resources large enough to enable them to develop these areas as complete estates with their own factories attached. A grant of this type must be such as to allow the planting of not less than from 500 to 1,000 acres, as well as to provide for factory, roads, houses, and gardens for the workers. An alternative system would be that of granting quite small units to settlers, with a guarantee that from one source or another a factory will be provided for the manufacture of leaf when planting has reached a stage of development which will

render it necessary. There is a great deal to say for this method of developing the possible tea areas of Tanganyika, but it must be recognised that a settler would have to be provided with a capital of not less than £2,000 and probably considerably more.

A third possible method of developing tea cultivation would be the encouragement of small peasant plantings of tea, varying from half an acre upwards, the peasants selling the tea to a central factory. This is a method which has prevailed in China from time immemorial, and is now being developed by the Russians in Georgia. Dealing with the objection that such small patches of peasant tea would get into bad condition, and become centres from which pests and blights would spread to the larger plantations, the author does not consider that there would be any serious danger of this, and he would be prepared to recommend that peasant planting of tea should be encouraged as far as possible.

THE SUPPLY OF SEED

Government has hitherto encouraged tea cultivation by providing good-quality seed for planters and prospective planters. The author feels that the necessity for such assistance is still probably somewhat acute. The cost of seed is a serious factor, largely because of the difficulty of getting a really high-class article, and of the large quantity which is required to plant out an area of tea. The serious evils of planting tea from low-grade seed have been felt in many parts of the world, and it is essential that good-quality seed should be provided if tea planting is to be encouraged in Tanganyika. There is now in all Tanganyika areas where tea cultivation is likely to be successful, a seed-bearing area which will ultimately give seed of high quality. It seems likely, in fact, that little further import of East Indian seed will be required, but it is very important that the seed now available should be placed at the disposal of intending planters at the cheapest possible rate. This is particularly important, because otherwise there is always the possibility that very inferior seed will be bought and used. It would appear to be important for Government to supervise the supply of seed in Tanganyika. Whether good-quality seed should be provided free to planters is a question which can only be settled when the policy of Government with regard to the development of the industry is decided, but it is pointed out that rapid development of tea-growing is only likely to occur if a cheap seed supply is available.

Apart from alienation of land and supply of seed, can Government help in other directions if it is convinced that an extension of the tea area would be advantageous to Tanganyika ? The author points out that a very clear decision must be made, not only as to the areas where development is possible and desirable but also as to methods of development in each area. If it is agreed that a tea area should be developed, it would seem necessary for Government to make and maintain good means of communication to and from the blocks which are given out to the settlers.

It would enormously encourage the possibility of successful tea development if the small settler found on his arrival a clear-cut scheme showing not only the blocks of land available, but also at least an idea as to how their development could best be carried out. He ought also to find in each of the selected areas a competent adviser to assist him. The presence of an expert with knowledge of the special difficulties would be of immense value.

GOVERNMENT AND LABOUR

With regard to labour, difficulties are almost certain to arise unless Government takes up the matter in the spirit of a trustee not only for the planting interests, but also for the labouring population. It is therefore urged that a Government representative should constantly be in readiness within fairly close access to any tea area which has been or is being developed. It is pointed out also in regard to labour that the short-contract system, used in connection with both sisal and coffee, would not be satisfactory for tea. Consequently, the development of tea cultivation may mean the permanent removal of units from their tribal headquarters, and the consequent foundation of units separated from their tribal leaders.

Concluding, the author says that, given development on the lines suggested, he sees no reason why, in the comparatively near future, there should not be in Tanganyika a tea industry with an area up to a maximum of 50,000 acres, meeting all local needs, and producing a large excess for export.

THE CLOVE INDUSTRY OF ZANZIBAR*

STEAMING down the East Coast of Africa at the season of the year when the south trade winds blow it is possible to smell Zanzibar long before one actually sees it, for the scent of cloves lingers in the air many miles out at sea. This perfume promises romance in sun-flooded surroundings and the traveller, be he government official, commercial representative, or pleasure cruiser, will not be disappointed. Coming up out of the sea mist there is the Island itself, resembling a light blue, floating cloud, and after a while the shaggy heads of tall palms appear, dotted on an uneven coast-line. From a sea of turquoise blue a strip of white beach appears, and with the glasses it is possible to see the clove plantations, or shambas, on the slopes of the low hills in the interior of the Island.

Zanzibar, and its adjacent smaller island of Pemba, practically supply the whole world with cloves, considerably more than 90 per cent. of the total crop coming from these two British Dependencies. But while the clove is indigenous to the tropics, it was only about a century ago that it first began to be cultivated in the islands. Its first home was in the East Indies, in the Molucca Islands, and it was said to be brought to Zanzibar by the Oman Arabs in the early nineteenth century. Since that time it has gradually become a flourishing industry. Soil as well as climate makes for success in a clove plantation. The former has to be of a rich red loam and well-drained. In Zanzibar and Pemba, the soil is the most suitable for consistent crops, and both islands, being of coralline rock the drainage is mostly perfect. In the larger islands, the plantations come to within four miles of the city of Zanzibar, whose streets during the long harvest always smell of the clove.

The plantations extend over a considerable portion of both islands. A visit to one of these "spice factories" is a memorable occasion, on account of the unique olive green beauty of the serried ranks of the trees. Some call them bushes, for they have only about from four to five feet of trunk, before the branches begin, which rise from 25 to 40 feet in height. They might be called giant perfume bottles, and during some seasons the perfume given off from both clove and leaf is overpowering.

The clove trees are planted in long lines about twenty feet apart, running east and west, so as to ensure the crop having the maximum sunshine. Two crops a year are gathered from each tree. The trees are raised from seed or from seedlings, and great care has to be taken with them for the first two years, especially to guarantee their being watered regularly. The fifth year brings a first harvest, but from the seventh year on the trees bear well. Their average life is approximately eighty years, with constant care.

The cloves are found in bunches of from ten to fifteen, hidden beneath the leaves, and are ready for picking after about four months' growth. The clove as we know it is really the unexpanded flower-bud, which, if

* By Arthur Lamsley, in *The Crown Colonist*, June 1933.

allowed to flower, would be of no use afterwards for the article of commerce which is so valuable. Usually the harvest begins in July and may continue in a favourable season to the end of the following January, or even into February. The cloves are gathered when they are a pinkish colour. It is a unique sight to see a tree in full bud, the delicate pink against the varying greens of the clustering leaves. The yield from the trees vary in weight, but a good average crop would be about from 4½ to 5½ lb. of dried cloves per tree. But some trees on well-kept estates have been known to yield in a good season from 10 to 12 lb.

Arabs and Indians are generally the owners of the clove shambas; but unfortunately many of the Arabs, through dilatory business methods, have their farms heavily mortgaged to Indian money-lenders. The cloves are gathered by Swahilis, who, unless they are well supervised, are careless pickers. They climb the trees and gather the bunches of cloves into a bag which they carry around the neck. Often, branches are broken by their weight, or tender branches are deliberately broken off, so that the cloves can be gathered at ease on the ground. On many plantations I visited, dozens of trees were spoiled by neglect to supervise the pickers. Instead of climbing, I should have thought a telescopic ladder could have been used to far greater advantage, and that it would have easily paid for its introduction after two harvests. Major Pearce, when he was Resident of Zanzibar, tried to induce the owners of clove plantations to use more care in gathering the crops, and to think of the great loss caused through broken branches and trees. By using ladders, the native would actually earn more pay (they are paid for the amount of cloves they gather per day, and can earn as much as three shillings a day), and with greater ease. Considering that Government takes so much in taxation from the clove plantations it might by benevolent autocratic means induce the owners to use suitable ladders. In olden days a kind of scaffolding was rigged round the tree at harvest time, but obviously this is a cumbersome process and not worth the labour it would entail.

After picking, the cloves are taken to open spaces, drying grounds cut in the bush, where for several days they are dried in the sun. On some shambas, the cloves are allowed to dry on mats raised a little above the ground. The better managed have a concrete or cement platform made about a foot above the ground, and the cloves are placed on the mats there to dry and can be stirred about far more easily. This drying process is necessary to the clove of commerce. The clove depreciates about two-thirds in weight during drying. In these drying grounds hundreds of native women are employed to make the grass mats. At night just before sundown, the cloves are gathered into the drying mats and covered from the heavy dew which falls, which they would re-absorb if allowed to stay all night in the open air. When completely dried, ready for commercial use, the clove loses its pink colour and becomes the dull brown we see in the West.

During the drying, the cloves and stems are kept apart; both have their separate and special uses. The stems produce a small quantity of oil and the Germans used to extract a valuable dye from them. When thoroughly dry and passed by the inspector, the cloves are packed for shipment in bags made of matting and weighing either 35 lb. or 140 lb. These

bags are stacked in native carts, drawn by bullocks, and taken to Zanzibar beach where they await shipment from the passing steamers to all parts of the world. The average harvest in the two islands is about 10,000 tons of cloves of marketable quality, and might be worth anything up to a million and a quarter pounds sterling, according to the market price.

Every civilised country takes cloves from Zanzibar and Pemba, but the three biggest buyers are Great Britain, the United States, and India, the latter taking more than double the quantity of the others. In India, where spice is used with every meal, the clove figures very largely in the preparation of foods and cooking.

Oil of clove is the most valuable extract from the clove. It is used in all lands, and in numerous industries, especially in pharmacy and confectionery. The quantity of oil obtained from an average clove is about 16 per cent., and it is estimated that the stems contain about 5 per cent. Commercially oil of clove is also used in the preparation of some perfumes, and of the finest liqueurs.

Cloves were not looked upon not long ago as a splendid antiseptic, and one used to chew one to keep the teeth clean and as an aid to digestion. Cloves are efficacious also in the wardrobe, and besides being more pleasant to the senses than moth balls, they keep all manner of insects away. While on the East Coast of Africa I always kept cloves among my clothes and the scent gave a freshness to the air and acted as a stimulant in the hottest hours.

THE VALUE OF SCIENTIFIC RESEARCH TO AGRICULTURE*

IN this series of radio broadcasts it is the custom, as I understand it, for each Cabinet officer to do a little boasting about his own department. I am more than willing to do my share of that on behalf of the Department of Agriculture; but in my remarks I hope not only to discuss the past of this department, but also to consider its future.

Necessarily, that involves the new farm bill. By to-night I had hoped to be able to talk in some detail about it, but since the bill has not yet become law, detailed discussion will have to wait. In lieu of that let me discuss the view that the new bill is the logical next step in the work of the Department of Agriculture in particular, and of all governments in general.

In order properly to appraise the work of this far-flung department of the Federal Government, suppose we cut through a tedious under brush of official and legal language, and set forth, in plain words, what the Department of Agriculture was established to do.

If you have thought about mankind's struggle through the ages to build an orderly society, you will agree that there have been two primary problems; first, to produce enough food and fibre to feed and clothe us all; second, to divide what we produce as equitably as possible.

We have always had to be concerned with production. Whatever else man can do without, he cannot live without food. And that was no simple problem back in the days when men lived in tribes in the forest, and when the food supply depended upon a man's skill with crude weapons. When the first faint stirrings of commerce and industry drew men to live in large groups in cities, the problem of a food supply became even more acute. Those who lived in the ancient cities could not grow their own food and fibre. Those who remained on the farm had the new job of growing enough not only for themselves, but for other families in nearby cities. Thus the dependence of the city dweller upon the farmer is overwhelmingly real. It is the key-log in this structure we call modern civilisation.

And there were times when the structure was in danger of collapse, or indeed did collapse, because the key-log weakened and gave way. By reason of abnormal seasons, drought or food, famines came and wrecked whole segments of human society. It was customary to blame those catastrophes on nature. Man, weak creature, was powerless if nature chose to starve him or drown him or otherwise maltreat him.

Somewhere back in the ages, a few individuals, more daring, more imaginative than the rest, began to wonder whether that was true. They reasoned that though nature could not be ignored, it could be modified. Man began doing that when he learned how to make fire by rubbing sticks

* By Henry A. Wallace, Secretary, U. S. Department of Agriculture, in *Science* Vol. 77, No. 2003, May 19, 1933.

together. We have been modifying the behaviour of nature ever since, to prevent famine, flood and other disasters, until, as Julian Huxley puts it, man has done more in five thousand years to alter the biological aspect of the planet than nature has done in five million years. By putting nature in harness, so far as possible, we have solved mankind's first great problem—the problem of producing enough food to go round. We have solved it too well, as a matter of fact, but I shall speak of that later.

When it is possible for the farmers of a nation to increase production 50 per cent., while crop acreage is increasing only 25 per cent., we know that science has been at work. That is exactly what has happened in the United States during the past 30 years. In large part it is a result of the scientific work of the United States Department of Agriculture and the co-operating State institutions.

It was for the purpose of putting science to work in agriculture that this Federal Department of Agriculture was established by Act of Congress 71 years ago. Washington, Jefferson and Franklin saw the need for it even back in their day. The department was created primarily for scientific research, its main job always has been a research job, and I hope research will always remain a principal duty.

Of course it is not enough to discover facts: a public institution has also the obligation to see that the facts are made available to all who can profit by them.

When a plant breeder in the department develops a variety of wheat that is highly resistant to rust, the job of the department has not ended with that discovery. The new variety has to be tried out in various regions, in the field. Next, the results of those trials have to be made known to wheat growers. That involves publications, both technical and popular, and articles for the press, and radio broadcasting. Then the seed of the new variety has to be made available to farmers. The county extension agent may step into the picture at this point, and suggest that the interested wheat grower sow some of the new seeds in a test plot, alongside some of the seed he and his neighbours have been using in the past. And when the old and new varieties of wheat are up and are harvested, let the neighbours for miles around come into compare them, and decide whether or not the new variety is better than the old and worth investing in.

That is a thumbnail sketch of the way science is applied to agriculture in this country and it portrays a system that is the envy of many another nation. Sir Horace Plunkett, Ireland's great authority on agriculture, in 1928 was moved to describe the Department of Agriculture as "the most widely useful department in the world." I am inclined to agree, and I only hope that its future will be as brilliantly successful as its past.

Whether he knows it or not, every farmer in the United States is farming differently today—and better—because of the scientific discoveries resulting from State and Federal appropriations. The average hour of man labour and the average acre of land is undoubtedly 20 to 30 per cent. more productive today because of this scientific work. From the fundamental point of view—that of supplying the food and fibre needed by our modern civilisation—the millions of dollars spent by State and Federal agencies during the past generation have been abundantly worth while.

I appreciate that it is often difficult for the layman to see any earthly use in many of the things that scientists do and talk about doing. Of what value is it to you and to me, for instance, for a man to spend his time trying to discover the workings of nature? How can a man—we are inclined to say—do anything useful unless he works directly with the things that we all can touch and see, that we know have practical utility?

Well, when confronted by questions like that, I think of men like Faraday and Mendel and some of the scientists in the employ of the Federal Government. About a hundred years ago in England Michael Faraday was what we might call an experimental philosopher. He never concerned himself with the invention of machines. His sole aim was to learn something about the workings of nature. He discovered the principle of electro-magnetic induction, and if you remember your high-school science, you will recall that without that discovery, we would today have no means of putting electrical energy to work for us. Without Faraday the amazing inventions of Edison and Marconi would not have been possible, and your radio and your electric lights would not exist.

And Mendel, that cloistered Moravian monk who whiled away the hours studying plants and experimenting with the cross-breeding of varieties of garden peas—of what earthly use was all that? He did it because it interested him. But was it of any use to the rest of us? I can assure you that it was, for the principles he discovered have been employed by the plant breeders of today and developing more productive varieties of every plant that feeds and clothes you. Scientists like Mendel and Faraday were working in what we call pure science. They were trying to discover nature's fundamental secrets, but without thought of any practical avocation of their discoveries. Had some over-zealous administrator tried to restrict their curiosity to some specific object, or the immediate solution of some highly practical problem, we would have been deprived, in all probability, of their great discoveries.

It falls upon another group of scientists to apply these basic principles to the pressing problems of the world and turn them to practical account. Thus most of the scientific research in government departments is applied science. The surprising thing, however, is that even in the field of applied science far-reaching discoveries are made, often as a by-product of the immediate task.

One of the most famous examples was the discovery by the scientists in the Department of Agriculture some forty years ago, that a micro-organism found in the blood of cattle is the cause of splenetic fever, and that the disease is transmitted by the cattle tick.

During the years 1888 to 1893, four men spent most of their time trying to make that discovery. Splenetic fever had become a costly disease of cattle throughout the South. Home-made remedies, treatment by skilled veterinarians, alike proved futile. The disease was costing the live-stock industry, and ultimately the consumer of meat, many millions of dollars.

The four Department of Agriculture scientists, in the employ of government because they wanted to pursue scientific research without interruption, and at salaries sadly out of line with their worth to the nation—these men

kept doggedly on the job despite all sorts of obstacles and disappointments. The joy of achievement was their chief reward. And their achievement proved to be of lasting benefit not only to the livestock industry, but to all mankind, for their research was the first demonstration that a microbial disease can be transmitted exclusively by an insect host or carrier.

From that came the knowledge, at the hands of other scientists, that yellow fever, malaria, sleeping sickness and other maladies are similarly transmitted. From that flowed the successful control of yellow fever, for instance, which in turn made possible the building of the Panama Canal. So it can truthfully be said that the success of four Department of Agriculture scientists in discovering the cause of a cattle disease was a first step in the construction of the Panama Canal.

These scientists—by name Theobald Smith, Curtice, Kilgore and Salmon —of course had no idea of the far-reaching consequences of their discovery. They were intent on finding the cause of a cattle disease, not in discovering a fundamental principle in medicine. But that happens often in scientific research.

And at other times, a scientist may fail to solve one problem, only to solve another unexpectedly. Not long ago some chemists in the Department of Agriculture were examining molds-fungus growths, that is—to find one that would produce tartaric acid. Patiently they tested one after another, until they had exhausted the possibilities of 149 different molds.

Finally the 150th rewarded their long search with success—but not the success they were expecting. Instead of producing tartaric acid, the 150th mold unexpectedly produced gluconic acid. This is now used in making calcium gluconate, the only calcium salt that can be injected between the muscles, without causing abscesses, in treating certain human diseases. This salt used to cost $150 a pound. As a result of this research, it may now be had for 50 cents a pound.

Much of the scientific work of the department, however, calls for more than the ordinary equipment of a scientist. I am thinking of the plant explorers, the men who cut their way through treacherous jungles, or press on across the forbidden deserts of Mongolia in search of plants that we need here at home. Whenever you eat bread made from durum wheat, or enjoy a choice steak or pork chops from cattle or hogs fed on alfalfa and soybeans, or sample a package of dates or a crate of navel oranges from California or the New Satsuma oranges from Florida—whenever you enjoy any of these things, you are reaping the benefit of the work done by a handful of explorers employed by the Department of Agriculture.

If you live in the Gulf Coast region, you probably are familiar with the rise of a new industry down there, the growing of tung oil trees. About twenty-five years ago tung oil revolutionized the manufacture of varnish, but the oil had to be imported from China. Back in 1905 David Fairchild, plant explorer of the Department of Agriculture, brought the first seeds of the tung trees to the United States from the Yangtze Valley of China. Our plant industry men discovered, after a good deal of experimentation, that the trees do well in the Gulf Coast region, and the new industry is today firmly established there.

Not every trip of a plant explorer, of course, is so productive. Every trip has its dangers and its adventures, but frequently the results are slight. Yet the introduction of a navel orange or a useful variety of soybeans or a hardy wheat atones for many unsuccessful trips.

In one way or another, I have said, every farmer in the United States is farming differently today because of the scientific discoveries resulting from state and federal appropriations. To be specific and as up-to-date as possible, suppose we run down the list of research achievements reported by one bureau of the Department of Agriculture for the past year. Before me is a summarized report for the Bureau of Plant Industry, and among their accomplishments I find these items:

Established the superiority of five new hybrid lines of corn in Iowa tests; released, for the use of growers, two new lines of hybrid sweet corn that will be resistant to bacterial wilt; released, for the use of growers, a new wilt-resistant variety of tomato, known as the Pritchard; introduced a new blackberry variety, the Brainerd, especially adapted for the West and South, and also introduced three improved varieties of strawberry; developed new root-stocks for Satsuma oranges, and found new disease-resistant stocks for California grape vineyards; introduced a new sugar beet, U.S. No. 1, that is resistant to the costly curly top disease, and that also greatly outyields older varieties; tested some promising new sugar-cane seedlings, crosses of American and New Guinea varieties; reported distinct progress in breeding alfalfa that will be immune to bacterial wilt; developed a new variety of Egyptian cotton in Arizona.

As another part of its job, this bureau investigates the storing, handling and processing of foods. For the year under report the bureau scientists discovered, among other things, that putting apples in cold storage immediately after picking almost completely prevents soft scald; that adding sulphur dioxide to the saw-dust packing of grapes retards the development of mold; and that treating fruits with carbon-dioxide before shipment is as effective as pre-cooling in preventing spoilage.

That is a partial report of the research accomplishments of one bureau. It gives point to the statement that research can stabilize crop production and eliminate or reduce those hazards—of disease, of climate, even of soil—which make agricultural production uncertain. For it remains true that though drouth or disease or insect pests may raise the price of a crop by reducing the supply, such higher prices are cold comfort to the particular farmer whose cotton has been destroyed by the boll weevil or whose wheat has been hit by rust. I have, I think, a proper scientific respect for insects and diseases, but I question whether we ought to leave it up to them to determine the size of our crops and the level of our incomes. Nor can I forget that every year, according to Dr. L. O. Howard, the damage wrought by insects nullifies the labour of a million men.

If time and your patience permitted, it would be possible to cite instances to show how research has affected all our major farm crops and classes of livestock; how the patience, the skill and the informed imagination of scientists employed by the Department of Agriculture have altered the agricultural map of this country and modified the farm practices of every farmer

in the land. Many farmers are not aware of this, for the results of research reach the individual farm by an intricate, devious path, but they get there just the same.

If you will agree with me on that, I suspect you are at the same moment questioning whether this research has proved to be an unmixed blessing. For science and invention, you will say, have not only made it possible for us to produce enough to go around: they have made it possible for us to pile up towering surpluses, which in turn seem capable of bringing our whole economic system crashing down around our ears.

We cannot deny that, when scientists in the Department of Agriculture develop a variety of wheat that produces five bushels more per acre than the variety commonly grown, one result may be, and often is, too much wheat. When our modern knowledge of nutrition enables one bushel of corn to go as far as two bushels did in the pioneer days in feeding livestock, one result may be too much pork and lard.

Of late years the Department of Agriculture and the colleges have been aware of the problem. They have tried to meet it by helping the individual farmer adjust his own production to changing market needs. They have hoped that advice and complete information on supply and demand would suffice.

Where they have been remiss, in my judgment, is in declining to face the fact that the individual farmer cannot adjust his production intelligently, unless he knows, with some degree of certainty, that his neighbours will do likewise. And it is to face that fact realistically that the new farm bill has been drafted. The essence of it is collective action, by all the producers, to accommodate their production to the market that actually exists.

Our expenditures for science, our efforts at increasing productive efficiency have in no sense been unwise. Certainly no thoughtful person could approve the abandonment of scientific research, or the relegation of our machines to the ash-heap. To do that would be like abandoning the use of automobiles because we have automobile accidents. As a rule, the fault is not with the automobile, but with the driver.

It is not the fault of science that we have unused piles of wheat on Nebraska farms and tragic bread-lines in New York City at one and the same moment. Rather it is because we have refused to apply science to the development of social machinery, machinery that will regulate our economic system to the end that what we produce can be equitably divided.

I am not one to ask for less efficiency. I want more, and I know that we can get far more. But I want the efficiency to be controlled in such a way that it does more good than harm. I want to see the farmers of the South grow 300 pounds of cotton per acre instead of 150 pounds, and the farmers of the North 50 bushels of corn per acre instead of 35 bushels. I want to see the average milk cow yield 400 pounds of butter fat per year

instead of 200. And I see no reason why our hogs eventually should not produce 100 pounds of pork on the average from 6 bushels of corn, instead of from 9 bushels.

These things can all be done. The research now going on will make it possible, and will pave the way for countless new agricultural achievements as well.

Only the other day I learned that research now in progress indicates that crops grown in some regions of the nation have a higher nutritional value than do apparently similar crops grown in other areas. If further study bears this out, the consequences will certainly be far-reaching. We may have a new agricultural map a decade from now.

The research job, far from being done, is only well begun. We shall need new varieties of cereals and grasses to resist diseases better than those we now have. We shall have to keep cutting costs of production by increasing yields per acre. Methods of cultivation, like methods of feeding and managing livestock, must be subject to continuing investigation if we are to keep abreast of the continually changing economic world about us.

When our chemists, not long ago, discovered an economical method by which begasse, a sugar-cane waste, could be made into high-quality cellulose, suitable for rayon, we patted ourselves on the back for an achievement of considerable importance. But over in the Bureau of Chemistry and Soils is a small bottle of a brownish cellulose substance called lignin, which was derived from the corn plant after many years of experimentation. The chemist will tell you that lignin is one of the principal parts of woody plant tissues; that it can therefore be obtained in abundance; and that it may yield a startling new collection of products. Already he has discovered in lignin such compounds as phenol and creosal. Lignin may yet rank, in its rich potentialities, in its influence on disposing of farm wastes, with our major chemical discoveries.

No, the job of scientific research in agriculture is not over, nor will it ever be. But today we have a new job, a new field for experimenting—that of social control. Research to increase productive efficiency, to widen markets, must continue. Eliminate the less important research activities, in defence to the need for economy; get rid of the dead wood in our scientific organizations—but keep the men of science at the tasks which will always need doing. And add to the old job the one that has been begun so well, this new job of developing the machinery of social control.

Can we, do you suppose, become as efficient in our social experimenting as we have already proven ourselves in scientific experimenting? If this can be done, we can go ahead into one triumph after another in the scientific world. If it is not done, I fear for the future of our civilization.

The farm bill is an effort in the direction of such social inventiveness. In some ways, it is perhaps as crude as the first automobile. But I believe it is profoundly right in purpose, for it attempts a reconciliation between

science and social justice; and I believe it can be made to work, if the rank and file of the people of the United States—the men who grow our food, the men who handle and distribute it, the men and women who consume it—the new machine will work if all these people are genuinely hungry to distribute the fruits of science in a just way.

For that is our great modern problem. Having conquered the fear of famine, with the aid of science, having been brought into an age of abundance, we now have to learn how to live with abundance. Sometimes I think it requires stronger characters, greater hearts and keener minds, to endure abundance than it takes to endure penury. Certainly it requires a new degree of tolerance among competing economic groups and a willingness to subordinate the will of the few to the welfare of the many.

Personally, I think the last twelve years have imprinted this lesson deeply on all of us. I think we are ready, now, to reach out towards a new order. I believe we are ready to attempt to plan our economic life in return for stability and security. If this is true, then we have reached a great moment in the history of mankind. We have determined to become the masters rather than the victims of destiny. We are daring to bring the economic interests of men under conscious human control.

We may make mistakes along the way; we may have difficulty in mastering all the intricacies of an economic system that is full of puzzling contradictions; but if we operate our new social machinery with the spirit of social justice in all our hearts, I believe that it will work.

REVIEW

INDIAN HEMP

BINDING THE EMPIRE TOGETHER

INCREASED IMPORTS INTO THE UNITED KINGDOM

THE imports of Indian hemp into the United Kingdom showed a considerable increase in 1932, over those for the previous year. In fact the growing importance of sisal and hemp to the Empire has led Dr. S. G. Barker, Director of the Wool Industries Research Association, to codify the present knowledge of the character and properties of the fibre in a report:

Sisal; The Attributes of the Fibre and their Industrial Significance; issued to-day by the Empire Marketing Board and obtainable from H. M. Stationery Office, 1/- net. Since 1927 although there has been a decrease in world production and export, especially in Mexico and the Philippines, there has been a noticeable increase in the amount produced within the British Empire and the other important producing area, the Dutch East Indies. British East Africa alone is responsible for nearly one-third of the world supply, producing and exporting over 72,000 tons in 1931 against a world total of 230,000 tons.

Of the Sisal imported into the United Kingdom by far the largest proportion is produced in East Africa. It is interesting to note that the imports in 1932 were more than double those of 1931, whilst the quantity of manila coming from the Philippines fell to just over half. This fall in manila was due, however, more to a lessening of the requirements of shipping industry than to a partial replacement of manila in certain cords, etc. by sisal.

After examining the varying species of sisal, their method of reproduction and the harvesting (which begins in the fourth or fifth year of growth), the report analyses the fibre content of the leaf before proceeding to examine its form and enumerate its most desirable qualities. These appear best in the sisal grown in Java and East Africa, which generally gives a fibre whiter, longer and thicker than that grown elsewhere.

USES OF SISAL

Apart from local uses for such purposes as hammocks, hats, braid, sacking, the uniformity of length, quality and appearance with which the fibre can be marketed make it eminently suitable for the production of binder

twine, cords and fine yarns. But the rapid replacement of the binding machine by the combine "harvester-thresher" foreshadows a narrowing market for the twine, emphasizing the necessity of extending its uses for commercial purposes.

Tests and trials have been carried out at the Imperial Institute and by the Admiralty to prove the suitability of sisal for marine cordage. The results have been generally favourable and have warranted the partial adoption of sisal by the Royal Navy. The defects which have been noted are considered remediable by scientific investigation and research.

There is also need of enquiry into the utilisation of wastage which is considerable, only 3 per cent. of the leaf being used in fibre production. The remainder can be used as pulp for paper, or the juice—fermented—for the production of alcohol, but the economic advantage of these uses has yet to be proved.

THE ISSUE

The major problem that presents itself for solution is, as in other spheres, the discrepancy between production and consumption. The thought and research that have been applied to the cultivation of this plant must now be devoted to utilisation. Dr. Barker has endeavoured to show the paucity of real scientific knowledge of the attributes and characteristics of the sisal fibre. He believes that research which will reveal further details will be of benefit not only in the development of a sisal industry, but also in that of other fibres with which the tropical Empire is rich.

DEPARTMENTAL NOTES

THE RHINOCEROS OR BLACK BEETLE OF COCONUTS*

(Kalukuruminiya, Sinhalese. *Karuvandu,* Tamil.)

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NATURE AND EXTENT OF DAMAGE

THE Rhinoceros or Black Beetle, is well known wherever coconuts and other palms are grown in Ceylon. The damage to healthy palms is done only by the beetle stage (fig. 1), which flies to the crowns of palms and bores into the cabbage in order to feed on the juice or sap. On the head of the beetle is a horn which is used in tearing out the fibres which are gradually pushed out as the beetle bores its way in. Its mouth parts are not formed for biting off and chewing pieces of tissue, but are specially adapted for chiselling out pieces of fibre as it tunnels its way into the softer portions of the crown and for sucking up the sap which flows from the wounds. This beetle neither lays its eggs nor breeds in healthy living palms, but it is occasionally found breeding in dead or dying palms attacked by the Red Weevil or killed by disease, lightning, etc.

The Black Beetle attacks palms of all ages, sometimes causing serious *direct* injury and subsequent loss of crop. There seems to be no definite evidence that under Ceylon conditions it is ever directly responsible for the death of palms by its own unaided efforts. On estates where this pest has been allowed to breed in large numbers in old stumps and logs, in buried branches and other vegetable refuse, the emerging beetles have caused serious loss of crop by boring into the spathes and even into young and half-grown nuts.

The outward signs of damage by this pest are to be seen in all coconut areas by the ragged and tattered appearance of the mature leaves which are often badly notched (fig. 7). Sometimes the bases of the leaf-stalks are pierced with large holes, so that they often break off in high winds. These types of injury are the result of the earlier borings of the beetles into the young leaves and stalks while these are still closed up in the heart of the crown. Older palms may often show small permanent scars or holes on their trunks as the result of former injury by this pest.

The injury which this beetle causes *indirectly* is often more serious than the direct injury, since the wounds it makes in the crown may be attractive to egg-laying Red Weevils. The weevil grubs frequently kill young palms and cause serious injury to older palms as the indirect result of Black Beetle attacks. Apart from the danger of Red Weevil injury, unless the wounds

* Submitted as Revised Leaflet No. 21.

made by the Black Beetle are promptly treated after the removal of the beetles, then either the wounds may become infected with bacteria or fungi, or secondary decay may set in during wet weather; in either case death of the growing bud may result.

LIFE-HISTORY AND HABITS

Beetles.—The beetle (fig. 1) is a rather large dark-brown to blackish insect, usually reddish brown underneath, with a horn projecting slightly backwards from the top of the head. This horn is usually larger in the male than in the female. The latter has a thick mat of reddish-brown hairs on the underside of the end of the body. The beetles are active about dusk, but during the day they are sometimes to be found boring into the crowns of palms, where they go to feed, hiding inside decaying palm stumps and logs, or buried in heaps of manure and other vegetable refuse where they may have recently emerged from their cocoons on whither they may have gone to lay their eggs.

Eggs.—The female beetles, after feeding and mating, deposit their eggs in almost any dead and decaying vegetable matter. A list of such breeding places is given later. Each egg or group of eggs is embedded in a lump of vegetable matter (Fig. 2) so that the young grubs, on hatching, will be provided with food. The eggs (Fig. 2) are whitish to creamy white, rather long oval when freshly laid, but gradually swelling to nearly double their original size before hatching. They take from 12 to 18 days to hatch at Peradeniya, but this period may possibly be shorter under the warmer conditions in the chief coconut districts.

Grubs.—The young grubs are whitish with pale brown heads and six legs (Fig. 3). They have mouth parts suitable for biting and chewing their food which consists of fairly soft decaying vegetable matter. This passes through the body, soon giving it a dark greyish colour, especially towards the hinder end. This darker colour of the grubs is especially noticeable when they are about half-grown (Fig. 4). The older grubs are able to chew up and consume harder and more woody material, such as decaying palm branches, logs and stumps. Full-grown grubs have a tough, rather leathery, whitish skin which is not so transparent as in younger grubs; the fine hairs covering the body give it a tawny appearance (Fig. 5). These grubs, before preparing to form their cocoons, assume a dull creamy, rather waxy appearance, stop feeding and become inactive, gradually expelling the undigested food from the body. This inactive stage occupies from about 1 to 3 weeks. The total grub stage usually lasts from about 3 to 4 months at Peradeniya, but may possibly be shorter in the coconut districts. It may take as long as 6 to 8 months if the conditions are not favourable.

Pupae.—The full-grown grubs form their pupal cells or cocoons in various places depending on the nature of their breeding ground, but usually avoid pupating in their food material, if possible. For instance, grubs which have been feeding in stumps and logs often hollow out their cells in the surrounding harder portions, but sometimes the cell is made of the chewed up coconut fibre in which they have been feeding. This material is cemented together to form a rather large, hard, oval hollow cell. Grubs which have fed in manure or refuse heaps, or in buried vegetable matter usually make their cells in the adjacent soil at least one foot below ground level. The grub, after constructing its pupal cell, gradually shrinks to

about two-thirds its former size, and changes into the pupal stage after moulting for the last time. The pupa is pale brown at first, but becomes rather darker and velvety in appearance later on. It somewhat resembles the beetle in size and shape, except that the legs and wing-sheaths are folded under the body (Fig. 6). The pupal stage lasts from about 6 to 9 weeks at Peradeniya, and this includes a period of about 2 to 3 weeks during which the emerged beetle remains in the cell before coming out to feed. Under field conditions elsewhere this total period may possibly be shorter.

Breeding Places.—The Black Beetle will lay its eggs in any place where there is decaying matter, either animal or vegetable, of sufficient bulk to attract the egg-laying females. The grubs, and sometimes other stages of this pest, are usually to be found in any heap or pit containing manure of cattle or other animals, town refuse, decaying palm droppings (except nuts), dead grass, paddy straw, old cacao pods, etc., but it is mainly in the lighter, rather sandy soils of the coastal districts that large accumulations of buried or mulched refuse of all kinds become dangerous breeding places. The beetles also breed freely in the dead and decaying stumps and logs of such palms as coconut, palmyrah, areca, etc., which have been killed by the Red Weevil grubs, by disease or by other agencies, such as cyclones, lightning, etc. Black Beetle grubs have also been found occasionally in dead and decaying stumps of old dadap and of jungle trees.

It may be mentioned here that the Black Beetle *is not known to breed to any dangerous extent* in any of the following materials unless these become mixed with any of the above-mentioned breeding materials: (1) mulched or buried coconut husks, (2) the main portions of coir refuse dumps, or (3) creeping leguminous cover crops or the leafy and less woody portions of bush green manure plants mulched or buried alone.

CONTROL MEASURES

Against the Beetles

The collection of beetles from the palm crowns is carried out on many estates as a routine measure, but is of little value if beetles are allowed to breed freely in any of the places listed above. The removal of the beetles, unless very carefully done, may cause further injury to the palms if the wounds are left untreated, since these soon become attractive to egg-laying Red Weevils. After the extraction of the beetles, all wounds should first be treated inside with tar or other disinfectant, and then filled in with a mixture of sand and tar which is then covered with a plug of clay.

Against the Grubs

Since the Black Beetle breeds wherever coconuts and other palms are grown either as an estate crop or in private compounds in towns and villages, it is essential that both estates and gardens should be kept as clean as possible. These sanitary measures involve the disposal of all previously mentioned kinds of refuse in such a way that they do not accumulate in large masses for more than one month at a time.

Palm logs used for fence posts, temporary bridges, building purposes, etc., should be first split up within two months after cutting.

On Estates.—On no account should estates with lighter rather sandy soils practise the mulching or burying *in bulk* of any of the usual materials known to breed Black Beetle. Cattle manure, town refuse and other mixtures of this type should not be buried in pits or trenches or mulched in large masses, but should be spread thinly and evenly over the soil and turned in at intervals so as to add humus to these sandy soils. Cattle manure, etc., which has to be kept for any length of time should be examined once a month and all stages of the beetle should be removed and destroyed. Palm branches, logs and stumps should be burnt if possible every two months, to be on the safe side, and the ash mixed in with the soil.

In order to compensate for this destruction of valuable humus it is recommended that leguminous green manure crops be grown in alternate rows between the palms and turned in to the soil at least once in every two years, the other rows being then similarly treated in their turn.

On inland estates with heavier soils, experiments should be tried to see whether various kinds of refuse can be buried or mulched in bulk with safetv. This material should be buried under at least one foot of soil well pressed down. At the first signs of any breeding of Black Beetle this practice should be stopped and the refuse should in future be disposed of in the manner recommended for estates with lighter soils.

The addition of some poison to masses of buried manure or other refuse with the object of preventing the breeding of the beetle grubs or of killing grubs already there cannot be recommended at present, since the application of any suitable and effective poison would be likely to cause serious injury to palms manured with this poisoned refuse.

SUMMARY

The adults of the Rhinoceros or Black Beetle (*Oryctes rhinoceros*) cause direct injury to the crowns of coconuts and other palms by boring into the softer growing portions to feed on the juice flowing from the wounds. This damage only becomes evident later by the ragged appearance of the opened leaves. Wounds made by the Black Beetle, unless promptly treated, may attract egg-laying Red Weevils, the grubs of which can directly kill or seriously injure palms of all ages, but especially young palms, unless prompt treatment is given.

The Black Beetle does not breed in healthy palms, but goes back to any decaying refuse to lay its eggs for the breeding of the next generation. Therefore the regular destruction or proper disposal of all organic refuse of the types mentioned above will help to control this pest and prevent serious injury to the palms. Regular collections of Black Beetles in the crowns of palms is of little value if these beetles are to be allowed to breed unchecked in towns and villages and on estates.

NOTES ON THE CULTIVATION OF CURRYSTUFFS

W. MOLEGODE,
AGRICULTURAL INSTRUCTOR, KATUGASTOTA

IN view of the interest that is now being taken in the cultivation of currystuffs, spices, condiments, etc., and the efforts that are being made to replace the imported commodities by locally grown produce, notes on the cultivation of some of these crops may be of interest.

1. CHILLIES (*Capsicum frutescens*)

Chillies, of which there are so many types, are employed as an ingredient in the preparation of curries, pickles, chutney, sauces, and sambols, and take a very prominent part in the Ceylon cookery. The consumption of this condiment in Ceylon is enormous. The quantity imported in 1932 was 155,147 cwt. valued at Rs. 1,990,059/-. Fair quantities of chillies are grown in the Island. The Northern, North-Central, Eastern, and the drier parts of other Provinces more especially in the Southern, Uva, and Central Provinces, a fair amount is dried or cured for home consumption and also finds a way to important marketing centres. In the wetter areas chillies are grown for the green pods which have a ready market in this form. The demand for dry chillies is so large, especially in the larger towns, urban areas, and estate districts, that it has to be met with imported chillies.

Chillies can be grown throughout the Island and cured chillies of first rate quality can be produced in the drier localities. Any ordinary well-drained soil is suitable. They grow best in newly felled and well-burnt jungle land such as those prepared for chena cultivation. The soil should be worked to a depth of about 6 inches and brought to a good tilth to get the best results. If the soil is poor, it can be improved by an application of well-rotted farmyard manure applied a few weeks ahead and—well incorporated into the soil to which a liberal application of ash is made. Fresh farmyard manure should not be applied. Green leaves, especially Keppitiya (*Croton lacciferus*), is a favourite manure for chillies.

In the *chenas* chilli seed is sown broadcast mixed with other cereals. This does not give the best results. Seedlings should be raised in beds and transplanted.

Beds for nurseries should be prepared rather early and allowed to be thoroughly 'weathered'. After sowing it is necessary to cover the seeds lightly and protect the beds from strong sun and heavy rains. When seedlings are about six weeks old, they are transplanted at about $2\frac{1}{2} \times 2\frac{1}{2}$ feet. After transplanting, the plants should be shaded and protected from sun and heavy rains for a few days until they take root and get established in the soil. Land should be free of weeds and careful intercultivation is of great benefit. From about the third month from transplanting fruits or pods begin to mature and the plants will continue to yield heavily for several months.

1 to 1½ lb. of seed will give an ample supply of good seedlings to plant an acre. The average number of seeds in a lb. is about 80,000.

A yield of 1,250 lb. of dry chillies is a fair crop. With heavy yielding types and good cultivation double that quantity has been secured. Records are available in Ceylon to show that well cultivated gardens have given up to one million chillies per acre. When fully ripe and dried between 500 and 600 chillies go to a lb.

For curing or drying only fully ripe pods that have assumed the characteristic bright red colour should be picked. Picking can be carried out at weekly intervals. If possible, picking should be done in dry weather. Damaged and fallen pods do not dry well. In good weather chillies can be sufficiently dried in about two weeks. If rain is not expected the chillies spread out to dry can remain in the open day and night. When sufficiently dry the chillies should be stored in a dry place, either in boxes or sewn up in bags. Dry chillies will go bad, if insufficiently dried or badly stored.

2. CORIANDER *(Coriandrum sativum)*

Coriander is another indispensable condiment, and is also largely used for medicinal purposes. Very little of this is grown in Ceylon. The quantity of coriander imported in 1932 was 54,052 cwt. valued at Rs. 669,405/-. In India it is cultivated extensively both in the plains and the hills. In the Madras Presidency alone over 100,000 acres are cultivated with this crop.

Coriander is a short crop, taking from 4½ to 5 months. Sown in October-November the crop can be harvested in February-March. It is grown either as a pure crop or as a mixture. The seeds are preferably sown in shallow drills a foot apart, but may also be broadcast and thinned out a foot apart. Watering when necessary and keeping down weeds are all that is required.

A lb. of coriander contains over 50,000 seeds. 6 to 8 lb. for a pure crop or half that for a mixed crop is sufficient to sow an acre. A fair average yield is 350 lb. per acre.

3. CUMIN *(Cuminum Cyminum)*

Cumin (Sinhalese *Sududуru*) is yet another valued ingredient of Ceylon curries, and at present the whole of Ceylon requirements is imported. The quantity imported in 1932 was 12,491 cwt. of the value of Rs. 218,980/-.

Being a short and delicate crop it has to be cultivated with care. A well-drained soil of a fine tilth is required. The crop needs thorough manuring and light watering. It likes a mild climate. Seeds are sown in drills, which are placed 2½ feet apart and the plants thinned out to 2½ feet in the drills. Seedlings may also be raised in carefully prepared beds and transplanted 2½ × 2½ feet.

10 to 12 lb. will be required to sow an acre. A well cultivated crop will give a yield of 700 to 800 lb. of cumin seed. 1 lb. contains little over 100,000 seeds.

4. FENUGREEK *(Trigonella Foenum-graecum)*

Fenugreek (Sinhalese *Uluhal*) is also a necessary condiment and large quantities are imported into the Island.

This is a short crop and takes 3-4 months and is easily grown. It likes clayey loam soils. Sow in drills 3 × 3 feet on well-prepared soil. Water lightly and keep free of weeds. Sowing should be so regulated as to get a spell of dry weather when the crop is ripening. 20 lb. will sow an acre and yield up to 800 lb.

5. ONIONS AND SHALLOTS (*Allium Cepa* and *A. ascalonicum*)

Onions, called in the market "Bombay onions", (Sinhalese *Rata Lunu*) and shallots, the small red onions, (Sinhalese *Rathu Lunu*) are imported in large quantities. In 1932 the quantity of both imported was 503,393 cwt. valued at Rs. 1,650,566/-. The uses of both of these are too well known and need not be described here. Both are grown in almost the same manner.

There are many types of onions (*Allium Cepa*) and several varieties are imported and will be found in the market. They differ in colour, size, and also in flavour. The commonest is the large red onion; there is a large yellowish-coloured variety and there is the smaller silvery white variety.

A fair amount of onions is grown in the higher elevations and a good deal of shallots are grown in Welimada-Palugama district, in Jaffna, in Hewaheta, and in most large vegetable growing areas.

Possibilities with onions and shallots are immense and those who have studied the question are of opinion that Ceylon is capable of growing its requirements of shallots—the small red onion—and there are signs to indicate that it is more extensively grown now and is marketed in fair quantities.

Onions can be grown very successfully over a wide area in the higher elevations, wet low-country or dried districts.

The most suitable soil is a rich sandy loam, friable, well-drained and easy to work. One that will not cake in dry weather, or retain excessive moisture after heavy rains.

Onions and shallots are both raised from bulbs or seed. Bulb planting is expensive and needs about 1,000 lb. of bulbs per acre. Unfortunately seeds do not keep well for any length of time, easily and soon lose vitality and go bad. Imported seed has invariably failed. Onion seed can easily be raised, and locally raised seed has done well. A hundred to hundred and fifty sound onion bulbs specially planted for this purpose will grow sufficient seed to plant an acre. The bulbs should be planted in rows 2 feet apart and 1½ feet in the rows. Before planting the top of the bulb should be cut off. This will stimulate a vigorous growth of leaf and stronger flowering shoots.

Onions do best in an open situation. Seed is sown in drills made at 1 foot apart and covered with about half an inch of soil only. When sown deep, many seeds fail to germinate, and even if grown, will make abnormal growth of neck. When the plants are 3 or 4 inches high, they should be thinned out to about 9 inches in the drills. In the process of thinning out there will be a large number of seedlings which can be transplanted. If drill cultivation is adopted 3 or 4 lb. of seed will be required. 1 lb. contains over 100,000 seed.

Keep land free of weeds and water once or twice a week in dry weather. Avoid sowing during heavy rains as the tender plants will be beaten down. The crop will be ready to be gathered in 3 to 4 months, and should be lifted when the leaves have turned yellow and begun to die. Sometimes when the

bulbs are half-grown the leaves may become yellow and die down. This is due to want of treatment. In such a case an application of ash, watering or an application of weak liquid manure will be beneficial. After lifting, free the onions of any earth, and cut off the leaves and roots and dry well for few days.

The yield depends on the soil, climate and cultural methods adopted and may vary from 10,000 to 20,000 lb. per acre, but this may be reduced by about 30 per cent. in the drying process. Yields of 30,000 are known to have been obtained on highly manured and well cultivated lands.

Those who are taking to onion cultivation as a trial should for a start adopt cultivation of bulbs in preference to growing from seed. Planting from bulbs 6 to 8 fold can be easily secured. If bulb planting is adopted select small undamaged bulbs and plant them at about 9 inches apart for onions and 6 inches apart for shallots. Bury the bulbs only sufficiently deep so that when the new bulbs form they may be found resting on the surface rather than below the soil level. In planting bulbs of shallots, which are generally in bunches, one bulb per hole should be planted.

Bulb planting also gives a crop about a month earlier than when raised from seed. April-May is considered the best time for planting onions, because the crop is ready to be harvested before the September-October heavy rains. The smaller bulbs harvested can be used for planting out in October-November timing to lift the crop in the dry periods of January-February.

6. GARLIC *(Allium sativum)*

Garlic (Sinhalese *Sudu Lunu*) though not so universally employed as onions, is greatly valued for its medicinal properties and is much used for this purpose and as a flavouring agency in Ceylon. A very limited quantity of garlic is raised in the Welimada district and there is no doubt that it can be successfully grown on a more extensive scale in a larger range. It is a very paying crop. During 1932 the Island imported 23,117 cwt. valued at Rs. 578,443/-.

Cultivation of, and treatment for, garlic is very similar to that for onions except that almost always garlic is raised from the sets or 'cloves' of the bulbs. Though the garlic plant somewhat resembles the onion, it produces a compound bulb which is composed of a number of bulbils or 'cloves' which are bound together by thin tough membranes. These are arranged around the central shoot. Sometimes a bulb of garlic may be found to contain as many as 20 'cloves'. Each of these is a plant-bearing one; it is therefore that the garlic bulb is broken up and the bulbils planted individually. They should be planted at a distance of 6 to 9 inches apart. Thereafter follow cultural methods as for onions.

Unlike onions the garlic is less fleshy and more hardy. Its keeping qualities are therefore much better, and if thoroughly dried and carefully stored may be kept for a long time.

About 250 lb. of large size bulbs will give sufficient 'sets' for planting an acre. Yields of 2,000 to 3,000 lb. of dried garlic per acre can be obtained.

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 31 JULY, 1933

Province, &c.	Disease	No. of Cases up to Date since Jan. 1st 1933	Fresh Cases	Recoveries	Deaths	Balance Ill	No. Shot
Western	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	28	...	27	1	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	11	...	...	10	...	1
	Piroplasmosis	...	...	...	...	...	...
Colombo Municipality	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	28	...	27	1	...	...
	Anthrax	9	1	...	9	...	...
	Rabies (Dogs)	20*	2	...	...	...	20
	Haemorrhagic Septicaemia	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Bovine Tuberculosis	...	...	...	...	...	...
Cattle Quarantine Station	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease (Sheep & Goats)	120	5	112	8	...	...
	Anthrax (Sheep & Goats)	125	15	...	125	...	...
Central	Rinderpest	65	...	11	52	...	2
	Foot-and-mouth disease	3	...	3	...	...	...
	Anthrax	10	...	...	10	...	...
	Bovine Tuberculosis	1	...	...	...	(slaughtered	
	Rabies (Dogs)	...	...	...	...	...	...
Southern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	50	...	50	...	...	...
	Anthrax	...	...	...	...	...	...
	Rabies (Dogs)	1	...	...	...	...	1
Northern	Rinderpest	1553	228	302	1188	17	46
	Foot-and-mouth disease	4	..	4	...	...	...
	Anthrax	...	...	...	...	...	...
	Black Quarter	...	...	...	...	...	...
	Rabies (Dogs)	...	...	...	...	...	...
Eastern	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	52	...	51	1	...	...
	Anthrax	...	...	...	...	...	...
North-Western	Rinderpest	...	...	...	...	..	...
	Foot-and-mouth disease	116	113	110	6	...	...
	Anthrax	...	...	..	...	...	...
	Pleuro-Pneumonia (Goats)	3	...	...	1	...	2
	Rabies (Dogs)	2	...	...	1	...	1
North-Central	Rinderpest	1030	72	184	808	9	29
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
Uva	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	...	...	...	...	...	...
	Anthrax	...	...	...	...	...	...
	Bovine Tuberculosis	2	...	...	...	..	2
Sabaragamuwa	Rinderpest	...	...	...	...	...	...
	Foot-and-mouth disease	738	156	688	50	...	...
	Anthrax	...	...	...	...	...	...
	Piroplasmosis	...	...	...	...	...	...
	Haemorrhagic Septicaemia	5	2	...	5	...	...
	Rabies (Dogs)	6†	4	...	...	...	6

* 1 case in a Goat at the Slaughter House.

† 2 cases occurred during June, 1933.

G. V. S. Office.
Colombo, 7th August, 1933.

M. CRAWFORD,
Govt. Veterinary Surgeon.

METEOROLOGICAL REPORT

JULY, 1933

Station	Temperature				Humidity		Amount of Cloud	Rainfall		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Inches		Inches
Colombo	83·5	− 1·5	76·6	− 0·6	80	86	7·9	6·58	21	+ 0·46
Puttalam	84·2	− 1·3	77·7	− 0·6	80	84	6·5	0·34	5	− 0·44
Mannar	87·3	− 1·2	78·7	− 0·5	76	84	7·6	0·26	1	− 0·11
Jaffna	86·4	+ 0·6	78·5	− 0·9	84	89	4·5	0	0	− 0·84
Trincomalee	90·1	− 1·5	77·3	− 0·1	62	80	6·0	0·08	4	− 1·98
Batticaloa	92·5	− 0·2	76·5	0	53	73	4·2	0·35	2	− 0·83
Hambantota	87·2	− 0·9	75·6	− 0·6	72	88	5·4	2·35	13	+ 0·62
Galle	82·4	− 0·8	76·2	− 0·8	84	88	8·5	9·40	19	+ 3·38
Ratnapura	85·5	− 1·1	74·4	0	76	90	7·6	13·38	28	+ 0·77
A'pura	88·2	− 2·4	75·3	− 0·5	67	86	7·2	1·69	6	+ 0·44
Kurunegala	85·1	− 1·5	74·5	− 0·7	76	90	8·8	5·96	20	+ 1·95
Kandy	81·0	− 1·5	70·6	− 0·1	77	85	8·0	10·84	23	+ 3·46
Badulla	83·9	− 2·2	64·1	+ 0·6	62	91	5·4	7·71	6	+ 5·74
Diyatalawa	76·4	− 2·1	63·4	+ 1·5	59	72	6·6	6·86	8	+ 4·98
Hakgala	66·6	− 2·8	57·0	− 0·3	83	91	6·2	9·46	20	+ 2·81
N'Eliya	63·4	− 2·7	54·6	0	86	88	8·6	13·46	29	+ 1·77

The rainfall of July was above normal over the greater part of the Island, excess being most marked in the neighbourhood of the hills. Deficits in the monthly rainfall were mainly reported from the Southern and Eastern Provinces, and from the Jaffna Peninsula. The highest monthly totals reported were at Kenilworth Estate, with 31·26 inches, and Nortonbridge Estate, with 30·08 inches. The greatest excess above average reported was 13·03 inches at Woodside Estate.

10 reports of over 5 inches in a day were received, the majority of them for the 27-28th. The greatest daily fall reported was 10·13 inches, at Woodside Estate, on the 19-20th.

Both the barometric pressure and the pressure gradient across the Island were above normal. Winds at the coast were generally south-westerly, and their monthly means showed, on the whole, little deviation from normal, though occasional strong winds were experienced. Strong winds were, however, reported from up-country.

Temperatures were generally a little below normal. Day humidities were a little above their average, while at night the humidity in general showed no marked deviation from normal. Clouding was about the average.

Hail was reported from Mahadova on the 18th.

H. JAMESON,
Supdt., Observatory.